Research on Key Technologies of 3D Dynamic Scene Reconstruction in Virtual Reality

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Abstract. In the process of reconstructing dynamic scenes, the traditional 3D reconstruction will generate certain data interference and data transition problems due to the certain continuity of the collected data. A three-dimensional dynamic scene reconstruction scheme based on virtual reality is proposed. Virtual reality technology is an emerging technology. The key is to model the actual object to obtain a virtual image and present it to people. Three-dimensional reconstruction is one of the core technologies, including monocular vision technology, pattern recognition technology, support vector machine computing technology and sensor technology.

1. Introduction
Virtual reality technology is an important direction of simulation technology. It is a collection of various technologies such as simulation technology and computer graphics human-machine interface technology, multimedia technology, sensing technology and network technology. It is a challenging cross-technology frontier subject. Virtual reality technology mainly includes simulation environment, perception, natural skills and sensing equipment. The simulation environment is a computer-generated, real-time, dynamic, three-dimensional and realistic image.

The most common method of 3D modeling is to use modeling software. However, due to the inevitable data blocking and the transition of connected data, traditional modeling cannot guarantee the maximum definition, and the modeling effect is not particularly good. The virtual reality-based 3D reconstruction technique solves this problem well. Based on the virtual reality of 3D reconstruction, the monocular vision method is used for data acquisition and processing. A video camera is used as an image receiving collector for comprehensive image processing, data acquisition, visual capture and other three-dimensional modeling data measurement and acquisition.

The three-dimensional data information of the target object is obtained by using a computer modeling program. As an important bearing point of computer vision technology, 3D reconstruction technology based on virtual reality has formed a variety of theoretical methods based on the visual theory framework. Due to the difference in the number of video cameras used to capture data, one video camera is called monocular vision, two cameras are called binocular vision, and so on. There are trinocular vision and multi-view visual methods. According to the different modeling principles, it can be divided into rule-based visual methods, region-based visual methods, feature-based methods and model-based visual methods; according to the way of collecting data, it can be divided into passive visual methods and active vision method. This paper studies monocular vision technology.

2. Virtual reality based 3D modeling technology
The monocular vision technology, by which the images are acquired and usable, can be either a single image of a single viewpoint or multiple images of several different viewpoints. The method can
recognize the degree of shading, texture lines, distance points, outer contours, etc. This method is simple in equipment and simple in structure, and can reconstruct a three-dimensional model of the target object using only a single image or a few images. These matching points are used to describe and obtain coordinate information points of the spatial three-dimensional target object, thereby realizing three-dimensional reconstruction.

Support vector machine represents a set of learning techniques from the training data creation function. Training data usually includes input objects and objects that are expected to be output. The development of virtual environment involves network technology, parallel processing technology, artificial intelligence, high-performance computing technology, pattern recognition, sensing technology, computer graphics, image processing and other technologies, as well as sociology, aesthetics, meteorology, communication and physics. The degree of complexity in mathematics and other disciplines can be imagined.

Sensor technology, a connector assembly of a photosensor, comprising a housing photosensor, a multi-angle sensor connector disposed on the housing, a cable connecting the photosensor to an external circuit, and a cable connector disposed at one end of the sensor connector. When the refractive index of the environmental medium changes, such as vibration or temperature changes, the phase of the light wave changes when the sensing fiber passes through it. The phase modulation of the coherent light in the sensing fiber can observe the change of the interference result caused by the external environment change at the detection section, which is the working principle of the interference type optical fiber sensor.

3. Monocular vision technology dynamic scene design

3.1. Photometric stereo vision virtual reality design

Although the conventional shading method can reconstruct a three-dimensional model from a single image, the data information that can be obtained from a single image is less, and the reconstruction effect is actually not so good. So, in the Woodham, the SFS method was improved, and the photometric stereo vision method was introduced. The basis of the method is the luminance equation, as follows:

\[ D_i - \alpha \sum_{j \in \mathcal{N}(i)} \frac{g_j + g_i}{2} (d_j - d_i) + (1 - \Theta_i) \sum_{j \in \mathcal{N}(i)} \frac{\Psi_i + \Psi_j}{2} (d_j - d_i) = 0 \]  

(1)

Where: \((1 - \Theta_i)\) denotes the intensity coefficient of the reflected light from the surface of the object; \(g_j\) is the kinetic energy vector of the object; \(g_i\) is the refractive index of the light source; \(\Theta_i\) is the image pixel; \((d_j - d_i)\) represents the two-dimensional parameter transformation value. The value is the value of the response collected data to ensure the integrity of the data in the process of analyzing the data; \(j \in \mathcal{N}(i)\) represents the value range of the data collection point. Photometric stereo vision uses multiple sources of non-conjugated sources to obtain multiple images of the same object. The conjugate equations of different images are connected to solve the object kinetic energy vector \(g_j\) and the source refraction vector \(g_i\). Therefore, the currently used methods basically use multiple (4 to 6) light sources for 3D reconstruction, which are represented by a matrix:

\[
GH = \begin{bmatrix}
\sigma_1^1 & \sigma_2^1 & \cdots & \sigma_n^1 \\
\sigma_1^2 & \sigma_2^2 & \cdots & \sigma_n^2 \\
\vdots & \vdots & \ddots & \vdots \\
0 & 0 & \cdots & \sigma_n^r
\end{bmatrix}
\]

(2)

Where: GH matrix represents the collected data storage calculation mode; \(\sigma_i^j\) represents the number of convertible simplification conditions of the light source. By transforming the pixels of the simplified condition, the degree of clarity of the picture can be ensured during the process of guaranteeing the data conversion, and it is more suitable for the conversion of the data collected by the multi-object under
different conditions. The converted data needs to be identified before it can be used. The process is as follows:

\[
\begin{align*}
X_1 &= \frac{\sqrt{2}}{4} X_o \left[ -\exp(-i\beta) + \exp(-i\beta) \right] \\
X_2 &= \frac{\sqrt{2}}{4} X_o \left[ \exp(-i\beta) + \exp(-i\beta) \right] \\
X_3 &= \frac{\sqrt{2}}{4} X_o \left[ \exp(-i\beta) - \exp(-i\beta) \right] \\
X_4 &= \frac{\sqrt{2}}{4} X_o \left[ \exp(-i\beta) + \exp(-i\beta) \right]
\end{align*}
\]

(3)

Where: \(\exp(-i\beta)\) represents the high-order attribute distortion vector after data transformation, and the high-order attribute distortion vector can reflect the effective degree of the transformation process; \(X_0\) represents the variable parameter that the data can effectively retain during the transformation process; \(X_1, X_2, X_3,\) and \(X_4\) represent conversion success rates. Through the above process, the photographic stereoscopic virtual reality design data is obtained, and the information particle operator distribution image is shown in Figure 1.

3.2. 3D reconstruction

The principle of 3D reconstruction is mainly to obtain images by the RGB camera and the far-infrared camera in the same direction, so that the directions of the two cameras are parallel as far as possible, which is beneficial to reduce the computational complexity of the camera correction, and obtain RGB images and Depth image. In order to solve the problem that the two cameras have deviations from the center of the image due to different positions, the RGB image is first coordinate-transformed so as to be aligned with the depth image coordinates, and then calculated to obtain the \(x, y\) coordinate position of the spatial point, and finally the 3D coordinate point cloud data \((x, y, z, R, G, B)\) is displayed by the LOD hierarchical model:

\[
\begin{align*}
(x - x_1) + \Delta x &= -f \left( \frac{a_1 (x - x_1) + b_1 (y - y_1) + c_1 (z - z_1)}{a_3 (x - x_2) + b_3 (y - y_2) + c_3 (z - z_2)} \right) \\
(y - y_0) + \Delta y &= -f \left( \frac{a_2 (x - x_1) + b_2 (y - y_1) + c_2 (z - z_1)}{a_3 (x - x_2) + b_3 (y - y_2) + c_3 (z - z_2)} \right)
\end{align*}
\]

(4)

Where: \((x - x_1)\) is the difference prime number of the one-dimensional coordinates of the model; \((y - y_0)\) is the data check energy level variable of the two-dimensional coordinates of the model. After the first display, the collected data will be allocated in a certain area. The distribution result is shown in Figure 2.

![Figure 1. Distribution of information particle operators](image-url)
Figure 2. Distribution area of multimedia data

After the first display of the collected data, the photometric stereo check can be performed. The process is as follows:

\[
\begin{align*}
x &= S + a_0 + a_1 S + a_2 L \\
y &= L + b_0 + b_1 S + b_2 L
\end{align*}
\]  

(5)

Where: \(a_0, a_1, a_2\) are the effective values of the point three-dimensional coordinates of the photometric stereo verification process; \(S\) is the best photometric stereo check parameter value. It can intuitively obtain the point coordinates \(ML(x, y)\) and \(F(x, y)\) which can draw the image, which greatly improves the occurrence of visual disturbance and ensures the dynamic presentation of the dynamic scene.

3.3. Denoising

At this point, good imaging results can be achieved, but the reconstructed 3D dynamic scene must be denoised to ensure image integrity. The conditional limitation can denoise to achieve high accuracy processing. The conditions are divided into two cases, as follows:

\[
D(A, B) = \frac{V(A)V(B)}{4} \sum_{x=0}^{n} \sum_{y=0}^{n} f(A, B) \cdot \cos \left( \frac{(2A+1)\mu\pi}{16} \right) \cos \left( \frac{(2B+1)v\pi}{16} \right)
\]  

(6)

Where: \(V(A)\) is the case where the data loss is not lost in the normal denoising process; \(V(B)\) is the data mutation value. The denoising process data can be used to easily calculate and store data. The process is as follows:

\[
v_j^{r+1} = \begin{cases} 
V_j, & \text{min } V_j \\
\min \sum_{i=1}^{n} w_i^2 + v_i^{r+1} + v_i^k & m_k(t)
\end{cases}
\]  

(7)

Where: \(v_j^l + 1\) is the effective completion of the operation and storage process of the data; \(V_j\) is the data operation and storage rate parameter; \(\sum_{i=1}^{n} w_i^2\) is the superposition limit storage of the stored procedure. After the above process, the denoising process is completed, and the final reconstruction process is completed.
4. Simulation experiment analysis

4.1. Parameter setting
In order to ensure the effectiveness of the virtual reality-based 3D dynamic scene reconstruction scheme designed in this paper, the target parameters are set, and the acquired variation $X$ is within the range of [0.5, 1.5]; the process parameter $Y$ is set between [755.32, 795.79]. The continuation of the maximum retained parameter $Z$ is 53.2. The experimental reconstruction coordinate system designed in this paper is shown in Figure 3.

![Figure 3. Coordinate system of reconstruction](image)

4.2. Analysis of results
In the experiment process, the experimental results of the traditional 3D scene reconstruction scheme and the virtual reality-based 3D dynamic scene reconstruction scheme designed in this paper are recorded. The phototaxis of the dynamic scene of the traditional 3D scene reconstruction scheme is shown in Figure 4.

![Figure 4. Experimental results (1)](image)

The phototaxis of the dynamic scene based on virtual reality-based 3D dynamic scene reconstruction scheme designed in this paper is shown in Figure 5.

![Figure 5. Experimental results (2)](image)

It can be seen from Figure 4 and Figure 5 that the three-dimensional dynamic scene reconstruction scheme based on virtual reality is designed to be stable in the process of dynamic reconstruction, which ensures that the dynamic rendering effect is optimal.
Figure 6. Results of comparison test

Analysis results of Figure 6 show that the dynamic dynamic image of the virtual reality-based 3D dynamic scene reconstruction scheme designed in this paper can reduce the steady trend in the process of reconstruction and ensure the effective connection of data.

5. Conclusion

Virtual reality modeling technology has developed rapidly, and its ease of use, stability, and speed have been welcomed by users. This paper designs a three-dimensional dynamic scene reconstruction scheme based on virtual reality, and applies the monocular vision technology in virtual reality technology for data acquisition and processing. It is hoped that the research on 3D dynamic scene reconstruction technology in this paper can provide a good method for the reconstruction of dynamic scenes.

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