

Retraction

Retracted: Key Point Detection Method of 3D Network Model Based on Virtual Reality Technology

Wireless Communications and Mobile Computing

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

- (1) Discrepancies in scope
- (2) Discrepancies in the description of the research reported
- (3) Discrepancies between the availability of data and the research described
- (4) Inappropriate citations
- (5) Incoherent, meaningless and/or irrelevant content included in the article
- (6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

- [1] J. Sun, "Key Point Detection Method of 3D Network Model Based on Virtual Reality Technology," *Wireless Communications and Mobile Computing*, vol. 2022, Article ID 5650795, 6 pages, 2022.

Research Article

Key Point Detection Method of 3D Network Model Based on Virtual Reality Technology

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In order to meet the higher requirements of today's society for the details and fidelity of 3D models, a key point detection method for 3D network models based on virtual reality technology is proposed. The key technical steps include model normalization preprocessing, feature extraction, and similarity calculation. The 3D model retrieval test of cars, trucks, and buses is carried out using the VTFT algorithm. The results showed that in different databases, the highest success rate was 86.4% and the lowest was 77.10%. Practice has proved that this method can effectively improve the efficiency and accuracy of current 3D model processing and can better meet social needs such as games and entertainment.

1. Introduction

With the development of computer graphics and the improvement of 3D model acquisition technology and computer hardware technology, 3D models not only have a leap in quantity but also are more and more widely used. The main application fields include industrial product design, virtual reality, 3D games, building design, film and television animation, medical diagnosis, and molecular biology research. As shown in Figure 1, virtual reality is a computer system that can create and experience a virtual world. It is generated by a computer and acts on users through viewing, listening, touching, smelling, etc., to produce an immersive interactive experience for users. Immersion, interactivity, and conceptualization are the three basic characteristics of virtual reality system [1]. The digital entertainment industry represented by animation cartoon, online games, mobile games, and film and television products, with its unique and rich artistic forms and huge market prospects, has become another new economic growth point after the industry [2]. People are not satisfied with the display form of two-dimensional plane. In order to get more intuitive visual effects, three-dimensional model technology came into being [3]. Some subtle surface details on the surface of the model,

such as bumps, creases, and wrinkles of the model, are usually very sensitive features in visual cognition. 3D modeling software is used to draw 3D models with high fidelity, and the effective operation of surface details makes them have special visual effects. The main function of the high-quality intelligent 3D model library management system is to establish a reasonable and reusable 3D model library with intuitive 3D model retrieval capability [4]. At the same time, this is also an open system, and animators can continue to supplement data as needed.

Nowadays, not only a large number of 3D models exist but also a large number of 3D models are generated every day. Facing the huge three-dimensional model database, how to quickly search the required model has become an urgent research topic, which involves the knowledge of computer graphics, computer vision, pattern recognition, and other fields. In the international standard MPEG-7, it has also been stipulated that the relevant media data include not only two-dimensional multimedia information but also virtual multimedia information such as three-dimensional models and three-dimensional scenes [5].

With the development of scientific and technological life, the actual combat scene is built through the virtual reality

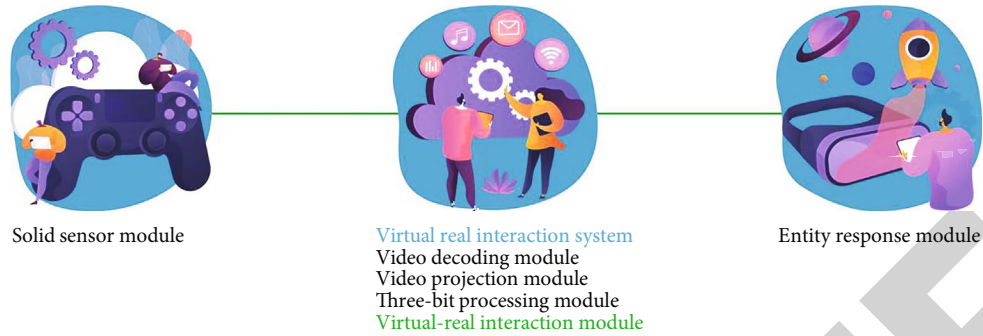


FIGURE 1: Virtual interactive system.

simulation platform, and the action and posture information of the human body is collected through relevant equipment to interact with the virtual scene. In addition to improving the sense of experience of game operation, the combat and training can also be carried out in the virtual combat scene, so that the soldiers' combat skills can be improved [6]. In addition, the virtual environment can also provide some complex human interaction and behavior tracking to cooperate with the simulation system for testing, training, and control, which has considerable potential and research significance.

2. Literature Review

Human posture recognition has always been one of the hot areas of computer vision research. The main purpose is to predict the human posture types in video by computer and to divide the correct prediction results into the corresponding posture type labels. Luo et al. used the dense trajectory (DT) algorithm to extract the track of video dense tracking by using the optical flow field [7]. Each block is calculated, and the motion information in the video and the surrounding environment are intensively extracted to capture the motion information of the video. At the same time, the gradient histogram (HOG) and optical flow histogram (Hof) corresponding to each block in the trajectory motion process are extracted to describe the surface features and local motion information in the video, respectively. In addition, the motion boundary information histogram (MBH) is introduced to improve the accuracy of pedestrian posture detection in the video, and good classification results are achieved on several large behavior recognition data sets. On this basis, an improved dense trajectory (IDT) algorithm is also proposed. Through the optimization of optical flow images, surf features and dense optical flow information are used to match feature points to improve the estimation of camera motion position, so as to eliminate the impact of camera jitter [8]. The L1 regular expression is used to normalize the features, and the accuracy is 91.2% on the data set ucf50. Miklós et al. adopt the single stream convolution method, use the pretrained conv2d neural network, and extend the information connectivity of the fusion time series to extract the local space-time information of the video and greatly improve the operation performance of CNN. It uses a single architecture to fuse the video frame information in the

final stage. The disadvantage is that because the spatiotemporal feature points do not capture the posture characteristics of the characters when they are moving, it becomes more difficult for the neural network to learn effective features [9]. Wu et al. in the direction of single stream convolution, combined with the advantage that RNN neural network can further map the input of video length, further proposed long-term time recursive convolution neural network (LRCN), added LSTM layer after convolution module, weighted and averaged the predicted results of input RGB and optical flow information, and finally obtained the best results. The whole network architecture is an end-to-end training and learning framework [10]. Pan et al. proposed 3D convolution neural network (C3d). Compared with 2D convolution network, the biggest difference lies in the use of 3D convolution block for convolution. The convolution result is no longer a 2D feature map, with more time dimension feature information, and has good generalization performance and compression performance [11]. However, compared with the recognition results of 2D convolution on static pictures, the effect of human posture recognition is not ideal, and the training process needs to occupy a lot of computing and memory resources.

On the basis of current research, this paper proposes a 3D model retrieval technology, which is a content-based retrieval method. Firstly, model standardization preprocessing is carried out. Then, the features of the 3D model are extracted, and a set of feature vectors are obtained. Finally, 3D model retrieval is realized by comparing the similarity between feature vectors. The key technical steps include model standardization preprocessing, feature extraction, and similarity calculation.

3. Method

3.1. Feature Extraction Algorithm of Rigid 3D Model. At present, most algorithms for feature extraction of rigid 3D models focus on 3D model retrieval between different categories. These algorithms are mainly divided into four categories. These four kinds of algorithms can be further divided into many subclasses. We mainly introduce the classic algorithms, as shown in Figure 2.

- (1) Statistical feature-based extraction algorithm: as shown in Table 1, the method based on statistical

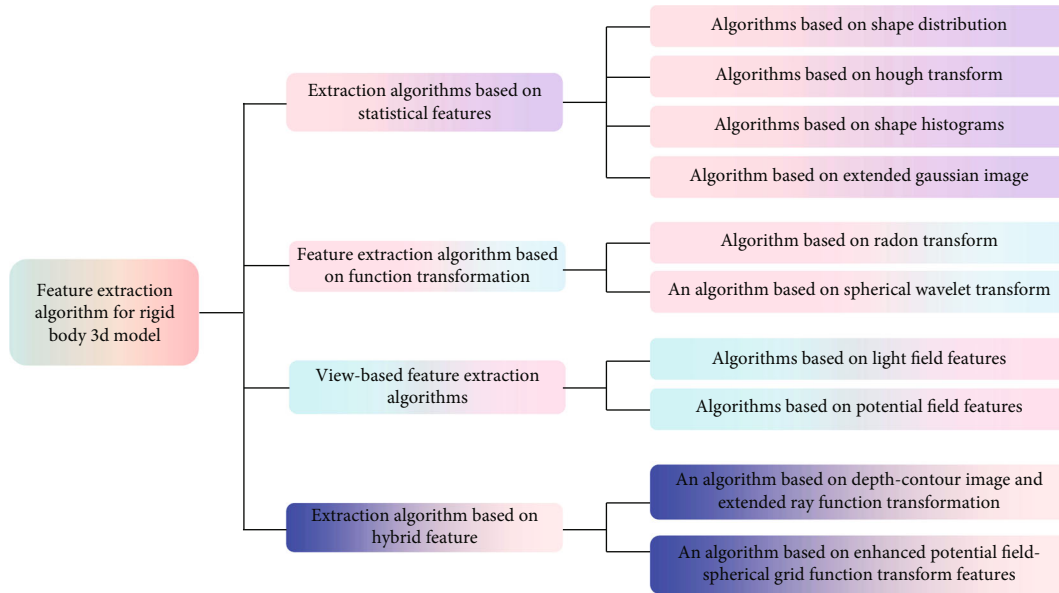


FIGURE 2: Classification structure of feature extraction algorithm for rigid 3D model.

TABLE 1: Comparison of feature extraction algorithms for rigid 3D models.

Feature extraction algorithm	Advantage	Shortcoming
Statistical feature-based extraction algorithm	Feature extraction requires a small amount of computation, features have good invariance, and there is no need to standardize the model	These features do not adequately describe the content of the three-dimensional model, and the recognition ability is not high
View-based feature extraction algorithm	The three-dimensional model is projected into two-dimensional images from different perspectives, which greatly reduces the complexity of matching. The extracted features are relatively simple and easy to calculate and generate indexes	The process of projection needs different constraints, so it is easy to lose some important information to represent the three-dimensional structure
Feature extraction algorithm based on function transformation	The analysis space is different from the spatial space, so this kind of features and other features have a good complementary effect, can provide multiresolution analysis, can achieve coarse to fine description, and can better describe the three-dimensional model	It is necessary to normalize the three-dimensional model, but some models are difficult to be expressed in the form of function, and the amount of calculation for feature extraction is relatively large
Extraction algorithm based on mixed features	The comprehensive application of two or more features can fully describe the three-dimensional model	The fusion of multiple features sometimes results in feature redundancy and a large amount of computation for feature extraction

features mainly calculates the accumulation degree of geometric features on a specific dimension in the feature space. It is characterized by simple calculation and fast speed, so it is widely used in the field of 3D model similarity calculation. This method has good invariance and does not need the standardized pretreatment of 3D model. However, the description ability of this method is generally not strong enough, and the description of three-dimensional model is not enough

(2) View-based feature extraction algorithm: in this method, the 3D model is projected into a set of 2D

images, and the 3D model is described by the features of multiple images obtained from different viewpoints. The idea of this method is that if two 3D models look similar in all directions, they are considered to be similar. The research focus is on where to dye the image, how many images to render, and how to organize these images. This kind of method can use more mature image matching technology to reduce the complexity of matching. The extracted features are relatively simple and easy to calculate [12]. However, in the process of projecting a 3D model into an image, it is necessary to make conditional constraints to project at the vertex of a regular polyhedron or an

approximate regular polyhedron, so it is easy to lose some important information representing the 3D structure

- (3) Feature extraction algorithm based on function transformation: transformation feature refers to the mathematical transformation of the three-dimensional model, and the transformation coefficient is used to describe the feature. Because the transform domain uses the analysis space which is different from the spatial domain, this kind of feature has a good complementary effect with other features. Moreover, the transform domain signal can provide multiresolution analysis of features, can realize the description of features from coarse to fine, and can better describe the three-dimensional model, but the amount of feature extraction calculation is large [13]
- (4) Extraction algorithm based on mixed features: from the above analysis, it can be seen that each method has both advantages and disadvantages. Therefore, recently, some scholars proposed to comprehensively use two or more features to complement each other, so as to improve the accuracy of 3D model retrieval

3.2. Feature Extraction Algorithm Based on Function Transformation. After extracting the view features, we only get the “outer” features of the 3D model. In order to obtain the “inner” features of the 3D model, we extract features based on function transformation [14]. The feature extraction of function transformation is realized by using two forms of three-dimensional transformation: radial integral transformation and spherical integral transformation. Before extracting the feature of function transformation, the 3D model needs to be voxelized. Because the view features of the 3D model have been extracted, it is not necessary to voxel the outermost surface of the 3D model. The systematization process is to first calculate the bounding box of the 3D model, which is the same as that used in rendering 2D images in the section, as shown in the figure. Then, the smallest box surrounding the 3D model is divided into equal voxel blocks. We divide the box into $64 * 64 * 64$ meshes, as shown in the figure. Each small voxel block forms an independent element v . We binarize each cell as shown in the figure. When the mesh cell contains part of the 3D model, the value of the cell is defined as 1; otherwise, it is defined as 0, so that u represents the set of voxel blocks containing part of the 3D model inside the surrounding box. In this way, the description of the discrete binary voxel function is as follows:

$$f^{\wedge}(v) = \begin{cases} 1, & v \in U_{\text{In}}, \\ 0, & \text{others.} \end{cases} \quad (1)$$

The discrete binary voxel function is used to calculate the value of each voxel block. The specific process is as follows: scan the voxel blocks of the 3D model along the $X/Y/Z$ axis, respectively. First, determine the start and end voxel blocks, along each line of the X axis. Among them, the voxel blocks with $f^{\wedge}(v_s) = f^{\wedge}(v_e) = 0$ located between the U_s line segment

and U_e form a set S_x in each line. Similarly, S_y and S_z can be generated. The function value of the part of the voxel block that belongs to the intersection of three sets is set to 1; otherwise, it is set to 0. After completing the two-value voxelization of the three-dimensional model, we begin to extract the radial integral function transformation features and spherical integral function transformation features of the three-dimensional model. The radial integral function and spherical integral function are introduced, respectively, below [15]. Let u be the unit vector and r be the real value.

The integral expression of the three-dimensional Radon transform formula for the function on the plane $\Pi(u, r) = \{v | v^T \cdot u = r\}$ is as follows:

$$R(u, r) = \int_{v \in \Pi(u, r)} f^{\wedge}(v) dv. \quad (2)$$

The retrieval speed is measured by the average feature extraction time and average retrieval time. Table 2 summarizes the average feature extraction time and average retrieval time. Our algorithm is implemented on a PC configured with Intel-Core2Duo, 2.53GU7 CPU, and 2G memory. From Table 2, we can see that the VFTF algorithm proposed in this chapter is slower than the retrieval algorithm using a single feature. Compared with the other two hybrid feature algorithms, the VFTF algorithm is slower than the design algorithm and faster than the ARTED-SGD. Feature extraction is completed offline. The retrieval speed of the VFTF algorithm will not affect the real-time requirements of the retrieval system. Considering the retrieval accuracy and retrieval speed, VFTF algorithm has better retrieval performance [16].

3.3. Multiscale Key Point Detection. We first detect the key points of the model at a fixed scale and then establish an automatic scale selection mechanism to realize the process of multiscale key point detection [17]. We define the points that meet the following three constraints as key points. The three constraints are that the detected key points must have a high degree of repetition between the dimensional view and the 3D model of the same object. In order to extract invariant local features, a unique 3D coordinate base can be defined from the neighbor surface. The neighbor surface of a key point must contain enough description information to uniquely represent the point, so as to ensure that the local features extracted at the key point are unique and can be accurately identified. For a 3D model, it is likely to detect a large number of points that meet the above three constraints, which weakens the initial purpose of key point detection, which is to detect a limited number of key points and improve the efficiency of feature extraction [18]. We can use sparse sampling or random sampling to form a subset of key points for feature extraction. However, according to the two criteria of repeatability and local surface description ability, sparse sampling or random sampling cannot form the best set of key points. To solve this problem, we use the principal curvature based on the local surface as the standard metric to measure the quality of key points, which is mainly used to classify key points and select the best set of key points [19]. Figure 3 shows the relationship between key

TABLE 2: Comparison of time performance of six algorithms on and model base.

Performance	Average feature extraction time (s)		Average retrieval time (s)	
	PSB model library	ESB model base	PSB model library	ESB model base
Radon algorithm	5.26	5.09	0.27	0.25
LFD algorithm	4.43	4.26	0.24	0.23
Ed algorithm	4.19	4.03	0.22	0.21
Detail algorithm	3.97	3.88	0.33	0.32
ART-ED-SGD algorithm	6.31	6.23	0.39	0.38
VFTF algorithm	6.23	6.15	0.38	0.35

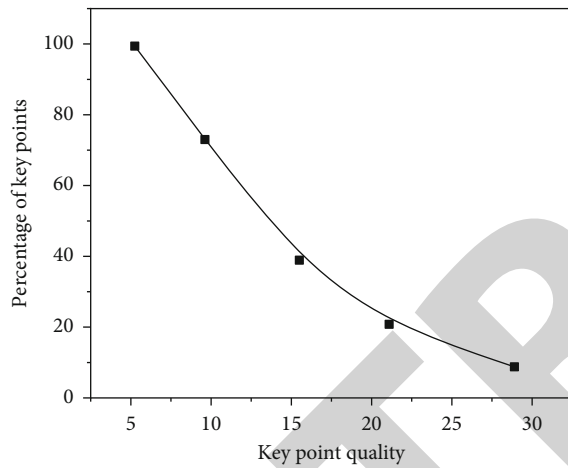


FIGURE 3: Key point quality and key point percentage.

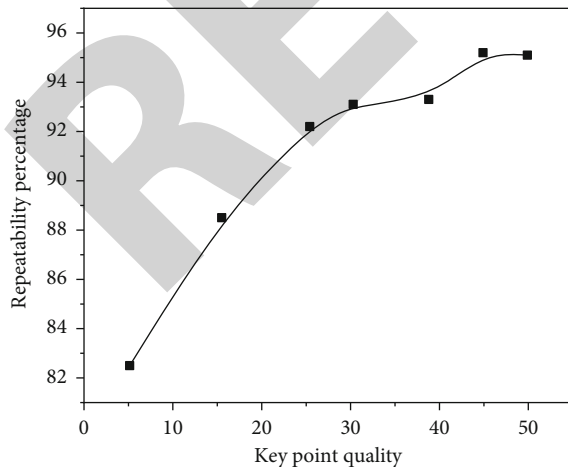


FIGURE 4: Key point mass and repeatability percentage.

TABLE 3: Retrieval performance analysis of VTFT algorithm in the created rigid body 3D model library.

Performance index Model category	MAR	MAP	F-measure	
			First tier	Second tier
“Car” category	82.4%	83.7%	75.3%	77.8%
“Truck” category	84.2%	86.4%	77.10%	78.9%
“Bus” category	83.6%	84.9%	80.5%	82.7%
“Human” category	77.3%	79.9%	71.6%	73.7%
“Trees” category	73.4%	75.2%	65.1%	67.8%
“Dog” category	76.7%	78.6%	69.8%	71.4%

quality and percentage of key points. It can be seen from the figure that the percentage of key points will decrease linearly with the increase of key quality. Figure 4 shows the relationship between the key quality and the percentage of repetition. It can be seen from the figure that the key repetition increases with the increase of key quality. It can be concluded from Figures 3 and 4 that the repeatability will increase with the reduction of key points, which shows that the quality of key points can correctly reflect the repeatability of key points.

After the key points are determined, we begin to extract features with invariance and strong description ability at these key points. We extract local features from multiscale key points by using local features of thermonuclear signals (HKS). The local features of thermonuclear signals are equidistant invariant and robust to topological noise, connection variation, and random sampling. However, HKS local features are sensitive to scale change. In order to solve this problem, we incorporate HKS local features into the feature bag framework. In the feature bag framework, the scale problem is transformed into a translation problem, and the translation invariance is achieved by quantifying the histogram to solve the scale sensitive problem [20].

4. Results and Discussion

In the general 3D model library (1400 3D models in total) created by our laboratory, we use the VTFT algorithm proposed in the third part for retrieval test, and the evaluation criteria also use MAR, MAP, and F-Measure. These 1400 3D models are formed by the combination of 800 models in the above three-dimensional model library and 600 models in the nonrigid 3D model library, including 63 categories. On all these classes, the experimental results show that the MAP is 75.4%, the MAP is 77.3%, the first tier is 73.1%, and the second tier is 74.3%. Table 3 shows the retrieval performance indicators using VTFT algorithm on “cars,” “trucks,” “buses,” “people,” “trees,” and “dogs” [21–23].

5. Conclusion

This paper presents a 3D model retrieval technology, which is a content-based retrieval method. Firstly, model standardization preprocessing is carried out. Then, the features of the 3D model are extracted and a set of feature vectors are obtained. Finally, 3D model retrieval is realized by comparing the similarity between feature vectors. The key technical

steps include model standardization preprocessing, feature extraction, and similarity calculation. By observing the retrieval performance data of VTFT, it is possible to successfully observe and establish a three-dimensional model, which will also be very helpful for the establishment of the game model.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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