Surface Design Method based on Image Denoising

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Abstract: In order to solve the issues like the feature detection algorithm surface design too sensitive to the presence of noise, this thesis proposes the grid processing algorithm. Firstly, the constrained smoothing model is used to smooth the grid, in which the bound terms are the sparse constraint terms of the error term of l_2 norm and l_1 norm. In the process of smoothing, the points of the smooth location move less, while the there is a greater movement of feature points. And then through the anglicizing the movement distances the initial feature points are extracted; finally, after the generating of the initial feature points, the feature points are more complete. Experimental results show that: the proposed algorithm can handle the noise of too sensitive.

Keywords: Surface Methodology; Grid Quality; Optimization; Feature Detection

1. Introduction

With the continuous development of 3D scanners and modeling techniques, the acquisition of three-dimensional model is becoming increasingly easy. Since the triangular grid is the simplest and most effective method to express the three-dimensional model, it is widely used in the field of computer graphics and computer vision, and many applications require maintaining the original features of the model, such as the characteristic grid security de-noising, net simplification, grid segmentation, mesh repair and so on, so the recognizing and extracting the geometry feature of grid have become the necessary steps [1-3].

The existing grid feature detection methods can be divided into the quadratic fit method based on plane or surface, the method based on curvature and the method based on normal vector. In addition, the detection problem of cloud feature is studied. Benk et al first fit a plane through the top point of the grid, consider the distance between the peak and the vertex plane, and then take peak whose distance more than threshed as the feature point to realize the dictation of grid features. Since the surface is represented by the discrete, for complex surfaces this method will be affected by the local dimensions of grid and curvature, for example the larger the grid dimensions and curvature, the greater the caused error, which results in feature extraction failure [4-6].

2. Grid Smoothing

Given a triangle grid $s=(v,r,y)$, where r, y and v respectively represent the collection of vertice, edge and face of the grid. X represents the matrix vertex coordinates with $n\times 2$, in which each row represents the three-dimensional coordinates of a point; X 'represents the vertices coordinates matrix of the smoothed grid. For the arbitrary point $v_i \in v$, its normal vector and the collection of the neighborhood points with one ring respectively represent n_i and $N(i)$. $d_i = |N(i)|$ represents the number of neighborhood points.

Local Laplacian vector of each vertex can be written in matrix form as the following:

$$X' = LX \tag{1}$$

Wherein, L is the Laplacian matrix of the grid.

$$(L)_{ij} = \begin{cases} 1, i=j \\ -1/d_i, (i,j)\in E \\ 0, otherwise \end{cases} \tag{2}$$

Nealen et al proposed overall smoothing algorithm based on mesh Laplacian.

$$\min_{\delta} \| L(X+\delta) \|_F^2 + \beta \| \delta \|_2^2 \quad (3)$$

Wherein, β is a parameter. Intuitively, the global Laplacian smoothing algorithm is making the whole mesh smooth enough under the circumstance of a little vertex offset. Global Laplacian smoothing algorithm smoothes the grid by optimizing the overall, which avoids sufficient of the iterations required by the local Laplacian smoothing algorithm (it is related to the vertices order of the iteration).

3. Grid Processing Noise Algorithm

In fact, the sharp features on the mesh surface are sparse, that is the proportion of the sharp features to all point vertices is smaller. Based on this observation, this thesis proposes a new feature grid extraction algorithm based on sparse optimization. As shown in figure 1, the position with the largest degree of grid smoothing is the position with the feature points. As shown in Figure 1b, the color bar from black to white indicate the distance from small to large; all the distance maps are using the same color bar, so by anglicizing the movement distance of the grid vertices, the feature points can be extracted (as shown in Figure 1c). However, the usual grid smoothing algorithm will make the flat position of the grid deformation, so the extracted feature points will contain a lot of false feature points. To overcome this problem, the proposed algorithm introduces the sparsity constraint item of l_1 norm, which makes the flat position in the grid move slightly or not move, so it is easy to separate the feature points and non-feature points. This method avoids the calculation of the second-order differential geometry, which greatly enhance the computing speed.

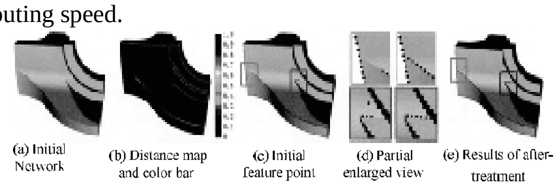

Figure 1. Algorithm flow

Extraction of Feature Line. By the processing section 3.2 and 3.3, the set F of the feature points has been obtained. The extracted feature points are lined to the feature line, as shown in Figure 2.

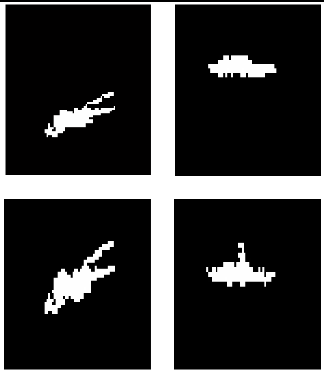

Figure 2. Extraction of feature line

4. Experimental Simulation and Analysis

4.1. Experimental environment and setting

Remarkable feature detection. Figure 8 shows he test results of the salient features with the proposed algorithm. In Figure 8a, black represent that the distance is small and white is the contrast; the other coolers represent the distance between the black and white. It can be seem that there is a big change occurred in the feature positions during smoothing, so after smoothing the distance of the feature points is larger than the non-feature points. The black points in Figure 8b, 8c are the extracted feature points. It can be seen, the proposed algorithm has the significant feature model, which can give a perfect result.

4.2. The noise model feature detection

The proposed algorithm is also applicable to the model with small amount of noise. The black points in Figure 8c and 8d indicate the extracted feature points. It can be clearly seen from Figure 8b, although Fandisk model is with noise, the distance of feature points is still large after smoothing, which ensures that the proposed algorithm can better extract feature points, as shown in Figure 8d.

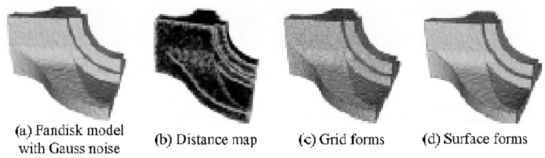

Figure 3. Test results of the noise model with the proposed algorithm

4.3. Detection of transition feature

Figure 4 shows the result of the detected transition characteristics with the proposed algorithm. Transition feature is located in the joint of the two smooth surfaces, as shown the features of the third raw in figure 4, which is formed with flat, cylindrical and spherical. So the characteristics are very weak, while it is hard to detect relatively good results with the methods based on curvature and normal vector, so curvature and normal vector in the transition are smooth. After smoothing of the surface stitching place, the moving distance of this point is larger than the ones in the flat position. The proposed algorithm can detect these transition characteristics.

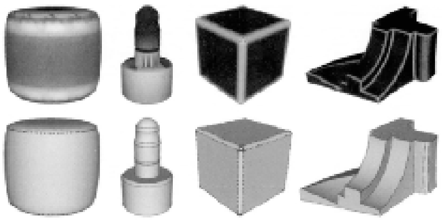

Figure 4. Test results of the transition characteristics with the proposed algorithm

5. Conclusion

This paper presents a grid processing noise algorithm. Firstly, the constrained Laplacian smoothing model is used to make mesh smoothing, in which the constraint items are the error term of l_2 norm and the sparsity constraint item with l_1 norm. In the smoothing process, the points in flat position move less, while the feature points have a greater movement. Then through the analysis of the moving distance of the vertices after smoothing to extract the initial feature points; finally, the initial feature points are processed to make the feature points more complete. The experimental results shows that the proposed algorithm can deal with sharp features of noise model and normal model, and also the fuzzy features and transition features can ne handled. The comparison of the testing results and the running time shows the high efficient of the proposed algorithm.

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