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Multi-view 3D Reconstruction Based on Edge Line Features

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Abstract

Traditional 3D reconstruction from multiple perspectives is mainly based on the detection and matching of feature points. In the actual target reconstruction scene, environmental light, target surface texture and other factors seriously affect the extraction and accurate matching of feature points, with poor matching effect and low robustness. In addition, the point cloud in the reconstruction process is complicated and requires a lot of computation, so the reconstruction process is time-consuming. Therefore, this paper proposes a method to obtain straight line features based on the edge, and uses this method to obtain straight line features from multi-perspective image sequences, and takes the straight line features as the underlying features to reconstruct the geometric structure of the building scene from multiple perspectives.Through the comparison of experimental results, this algorithm is better than the traditional multi-view 3D reconstruction algorithm based on point characteristics.Compared with the existing multi-view 3D reconstruction algorithms based on line features, it is advantageous to establish the position relation between line features and the position relation between regional texture and geometric model, which provides convenience for the texture mapping and mapping of 3D reconstruction geometric model results.

Keywords

3D reconstruction; Multi-view; Line feature; Edge.

1. Introduction

Three-dimensional reconstruction is one of the important research directions of computer vision, and three-dimensional reconstruction from multiple perspectives is another important method. It aims to accurately reconstruct three-dimensional geometry from a set of two-dimensional, multi-view images, a difficult and time-consuming task.

With the development of research, there are many solutions, such as Bundler[1] and openMVG[2], and visualization software, such as VisualSFM[3], which can automatically generate 3D models within hours by input of image sequences.Such method of Structure from Motion (SFM) is based on detection and matching of point features, and the number of detected point features is far from being able to completely express the whole scene compared with the reconstruction target, so the reconstructed results are sparse.Although already integrated dense reconstruction methods CMVS/PMVS [4 ~ 6], the input image data sets the, reduce the image data redundancy, improve the accuracy of the reconstruction, but the 3D reconstruction method based on motion recovery structure, in the feature extraction and matching are to point as the underlying characteristics, so vulnerable to rebuild the target surface texture and light, and many other factors, and the generated point cloud model in 3D model there are many shortcomings and limitations, such as large amount of calculation of point cloud, the memory cost, surface in low state of texture feature is less,The original model geometry cannot be reconstructed accurately.

To solve the above problems, based on the framework of the Line3D[7,8] 3d reconstruction algorithm for building scenes, the extraction algorithm of the linear features was improved, and a multi-

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perspective 3D reconstruction method based on edge linear features was proposed.Chain based on single pixel width on the edge of the linear feature detection algorithm instead of the traditional algorithm of LSD [9], the use of the target scene edge has a very rich geometry information, through edge detection algorithm of single chain of pixels on the edge of the image are extracted, and the edge processing of polygon approximation algorithm is linear features, by using the method of multiple points of view image data sets linear feature extracting, and matching and the target scene of 3D reconstruction. Finally, the paper analyzes the advantages and efficiency of the algorithm.

2. Extraction of Linear Features

In the scene of building objects, the number of feature points that can be matched is not large, so the number of accurate 3D point features is small. However, building objects have many linear features, which can be used for image matching.At the same time, the edge part of the image concentrates most of the information of the image, and has rich geometric structure properties, which is very beneficial for 3D reconstruction.

Therefore, the Edge detection of single image Edge Drawing[11] is carried out to extract the Edge of single pixel chain width in the image. Then, each Edge chain is polygonized by Douglas -- Peucker vector compression algorithm [12] (ABBREVIATED as DP algorithm), and the threshold of line length is set to extract the line segment meeting the threshold as the characteristic line.

After Edge detection of the image by Edge Drawing[11], a series of Edge line segments are obtained, and each Edge segment is polygonal in curve, that is, vector data compression.DP algorithm is used to screen the point set that constitutes the edge segment, so as to retain the key shape of the source data.The specific algorithm steps are as follows:

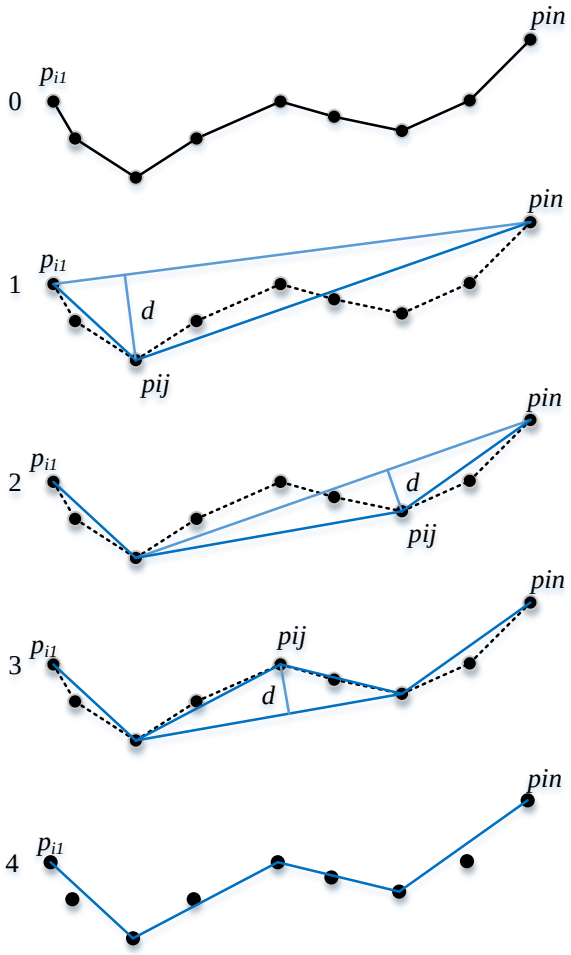

Figure 1. Diagram of edge segmentation process

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(1) For the point set $E_i\{p_{i1}, p_{i2,\ldots}, p_{in}\}$ of each edge segment, a line is connected between two points p_{i1},p_{in} at the beginning and the end of the curve, and the line is the chord of the curve $\overline{p_{i1}p_{in}}$;

(2) Get the point p_{ij} with the maximum distance d between the line segment $\overline{p_{i1}p_{in}}$ and curve;

(3) Compare the distance d with the preset threshold d_{thresh}. If it is less than d_{thresh}, the straight line segment will be regarded as the approximation of the curve, and this segment of the curve is processed.

(4) If the distance is greater than the threshold d_{thresh}, the curve is divided into two sections $p_{i1}p_{ij}$ and $p_{ij}p_{in}$ by p_{ij}, and the edge curves of the two sections are respectively processed for 1~3.

(5) When all the curves are processed, the broken lines formed by each segmentation point are connected successively. These broken lines are the extracted straight line features and serve as the approximation of the edge curve segment.

Through the comparison of relevant experiments, this paper thinks that setting the threshold d_{thresh}=3 is more appropriate.

3. Results Simulation and Analysis

The experiments in this chapter are all compiled and run under the memory hardware conditions of Intel(R) Core(TM) I5-8500 CPU (3.0 GHz, 6CPUs) and 8G, under the Cygwin X64 software platform.

The multi-view geometric 3D reconstruction algorithm based on edge line features proposed in this chapter conducts 3D reconstruction of geometric structure restoration for 4 different building scenes. The specific effects are shown in Figure 4 to Figure 7.

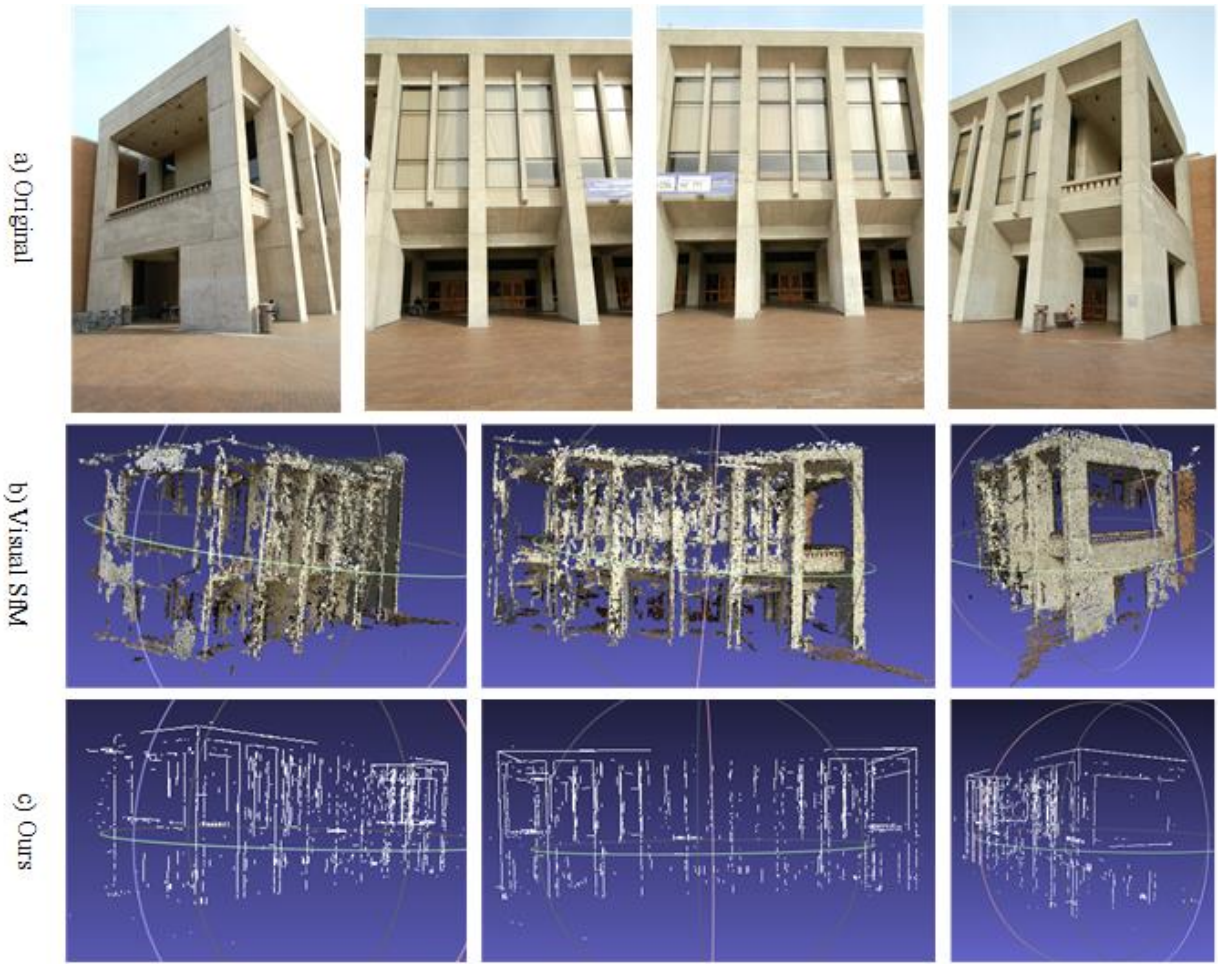

Figure 4 Comparison of 3d reconstruction algorithm results of Scene in Building1

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FIG. 5 Comparison of 3d reconstruction algorithm results in Site 2

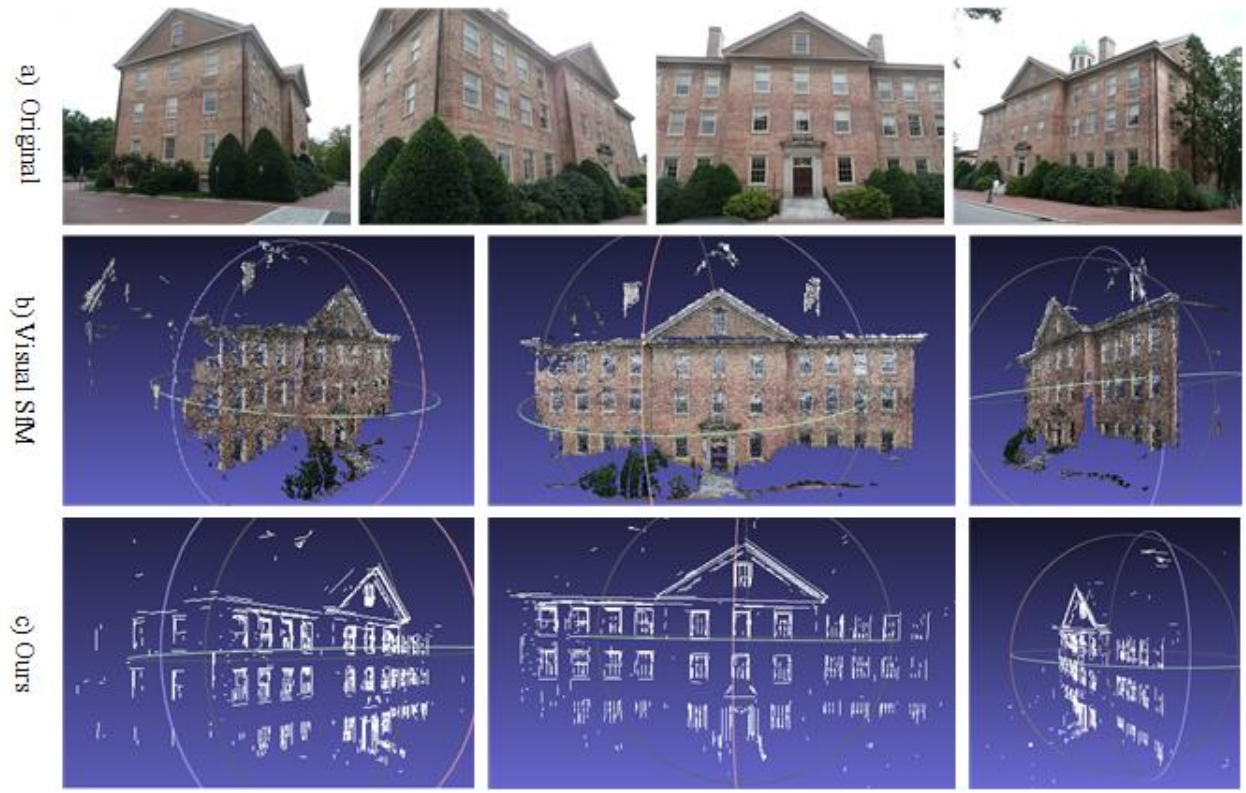

Figure 6 Comparison of 3d reconstruction algorithm results in Building3 scene

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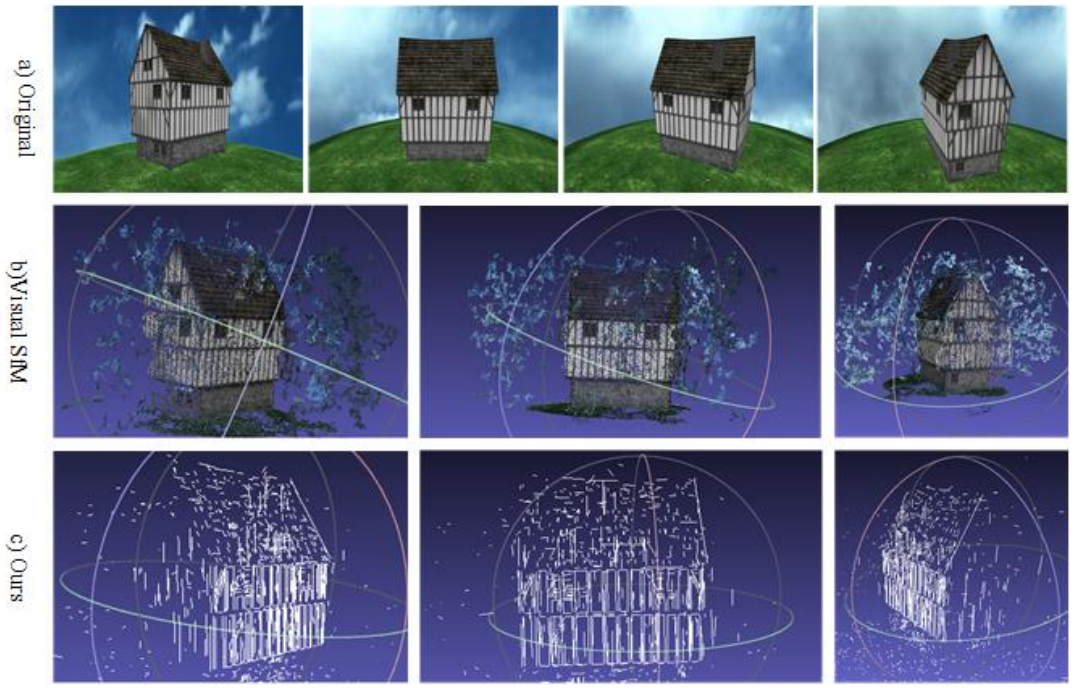

Figure 7 Comparison of 3d reconstruction algorithm results in Building4 scene

Through the experimental comparison results can be seen in table 1, the reconstruction of point cloud model often need a lot of space point to construct the three-dimensional structure of the target scene, and the geometrical structure of 3D model based on linear feature relatively speaking, due to the linear features than a single point is more abundant spatial information and so on reconstruction of the model structure has more power of expression, and therefore to reduce the amount of calculation.As can be seen from the experimental data in Table 1, compared with the point cloud model, the linear structure model can reduce the characteristic quantity required for model construction by a minimum of 6 times.Therefore, geometric structure reconstruction based on straight line has more advantages in reducing computation and form capacity of 3D model.

Table 1 Comparison of the number of features of point cloud model and linear structure model constructed in different scenes

Algorithm	Building1	Building2	Building3	Building4
Visual SfM	9190	7012	13850	24461
Ours	1453	526	1276	1357

At the same time, compared to other linear detection algorithm, this ZhangCai based on edge extraction of linear features, although its performance is not necessarily the best, but in the process of linear feature matching, makes the texture region associated with the spatial relationship between spatial model, the implementation of the regional texture mapping work is beneficial to the follow-up and implementation from the target scene to the geometric structure model and the real texture entire modeling process of the model.

To sum up, 3D reconstruction based on edge straight line features USES the straight line features existing in the edge curve of the target image to simplify the expression of the target 3D model, which has many advantages over the point cloud model in terms of high efficiency and good effect in the expression of geometric structure. In linear abundance of macro scenario buildings, for exterior wall

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are weak texture state, or local area, such as glass Windows and other adverse factors of the reflective, high brightness, the point cloud may emerge in the 3D reconstruction scheme of feature extraction, matching the quantity does not meet the constraint condition, eventually led to the 3D model parts of empty, without a corresponding model of point cloud data, etc., but in this paper, the algorithm is not affected by factors such as surface texture of advantage, the expression of the target scene extract with the geometric structure of line segment as a characteristic, and as a 3D model of form of expression, the better the results show the target scene model.

4. Conclusion

In this paper, a line detection algorithm based on edge features is proposed and integrated into the 3D reconstruction Line3D framework to carry out 3D reconstruction of the geometric structure of the target scene.Experimental test and result analysis show that the algorithm is superior and benign compared with the point cloud model, and the line detection based on the algorithm can obtain the location topological relation between feature lines, which is helpful for the mapping of model region texture.However, there are also some shortcomings, such as too fragmentary segment of line segment, and the matching process needs to be optimized to obtain more matching pairs, so as to reduce the phenomenon of partial structure missing in the model.

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