

Research of Texture Extraction and Mapping based on 3D Building Reconstruction

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Abstract

This paper proposes texture extraction and mapping methods from image of 3D building, 3D building in image can be reconstructed based on plane, through the correct input image. We propose a new method to eliminate distorted Distortion, in order to correct the texture image and estimate textures color by compensating for light color. This method avoids the middle of the process of 3D measurement. We proposed a texture mapping strategy based surface particle, a better solution to the shooting-related problems such as uneven lighting, high light and block light. We proved that the method can get enough quality through experiments, while the intensity of the image with different methods shows the efficiency correction.

Keywords: 3D; building reconstruction; texture; mapping

1. Introduction

Automatic 3D modeling by image computer is a challenging research topic, the topic is very important for many applications, such as a virtual city-aided design, augmented reality, and so on. There are a number of image-based modeling methods [1-7], the main focus of these methods is the scene, for example, Baillard and Zisserman [1] a collection of plane Debevec, which uses a combination of some methods.

Taking into account the workload of the virtual environment, through the acquisition of buildings on the plane texture in the picture of scene, Figure 1 shows a picture of the building, through the plane of the building recognition, segmentation, which plans to cover the entire buildings, the existing methods. Most of them are semi-automatic completion of the [8-10], usually consists of two steps: (1) fewer building characteristics (such as points, lines, etc.) reconstruction, as automatically using Structure from-Motion, technical photography. (2) Select the scene model and estimate its parameters, the first step by the characteristics of the building cluster, making it a higher level of the original geometric features, such as in the input image to

identify edge. The second step to optimize the combination of these model parameters is to reduce the difference of the predicted side.

These technologies are given a higher photo-like effect, but due to the increasing complexity of the scene model in recent years, therefore, a more efficient and automatically texture sampling, image correction, and texture mapping is proposed in this paper.

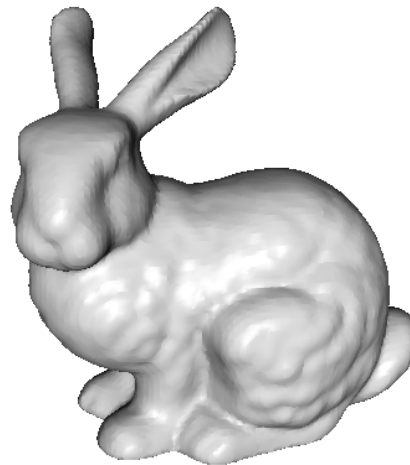


Figure 1. An Image of Planarity Model

2. Texture Sampling

Given a natural light plane image sequence $I_r(p)$, $\tau = 0 \dots T-1$, the corresponding color of the picture sequence Q_i can be described as

$$Q_i = I_r(p) \quad (1)$$

Where p_i is the visible point on the target image on the projection P_i , for all points on the target, the texture sampling is equivalent to the solution of equation (1) by 3D-2D mapping is solved by using the point P_i to obtain the image consistent point of p_i .

This paper proposes a different approach, the method gives the following graphic image sampling to avoid the use of 3D shape models, and additional calibration data, the main idea of this method is a temporary arrangement under natural light sequence $I_r(p)$ plane to the fact, each mapped to the point p_i in the plane τ' 3D target point, P_i is also located in the target plane of τ' in the target plane and the image plane τ' corresponds to and, therefore, by formula (1) τ' calculated, the RR contour line has all the points for texture sampling. At this point, the light intensity of the image model gets a virtual view of the target entity to adapt to each plane in the image plane contour deformation compensation. Finally, the plane index at $r = 0$, the planar arrangement of the similarity algorithm presents as follows:

- 1: According to the illumination model, it generates a virtual view and the plane τ' .
- 2: Line segments construct a single plane image, and then extract the boundary as a closed polygon chain. By the interpolation of multi-linear chain, it forms a continuous contour.
- 3: registered with an active contour model continuous contour, which replaced the natural light images of each plane with the true contour.
- 4: Surrounded by all the flat profile, and then, surrounded by each contour point p_i , Q_i corresponding to the three primary colors from these plane sampling.

3. Image Correction

3.1 Shape rectification and shape correction

In this paper, the quadrilateral corresponding to correct the deformation of the plane image, constructed for each quadrangle, the first correction homograph estimates, and then gives the optimized single correction of the distorted plane image.

Constructed through the designated boundary line source quadrilateral can usually designated quadrilateral as the end point of the fixed-point boundary line, but some point there may be outstanding or recessed features, so these feature points may deviate from the line segment between two endpoints, hence, based on the identification of the designated boundaries such as adjust the

position of the two boundary lines of the intersection of straight lines, in order to determine the vertices of the quadrilateral. Figure 2 (a) shows a structure of the source quadrangle.

Damage due to the process of perspective to capture the geometric relationship between the segments, we construct the target quadrilateral-based source quadrilateral and its approximate number of characteristics within the quadrilateral aspect ratio which should be the same here as an average approximation, because different flat-screen aspect ratio may exist a greater difference. Similar figures as close to reality as possible, during quadrilateral correction, construct source quadrilateral selected two vertices

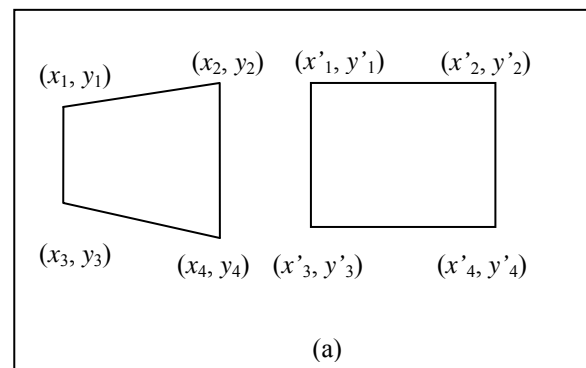


Figure 2. Shape correction of the source quadrangle of: (a) (b) the target quadrilateral

Flat images in the source quadrilateral first count related components analysis, use the common boundary quadrilateral side edges of the adjacent quadrilateral edge after the conduction of plane identification was confirmed. Aspect ratio in the target quadrilateral storage presents as follows:

$$lq = n \cdot hq \quad (2)$$

The parameter lq and hq are usually the length and height of the target quadrilateral, n feature points in the source quadrangle data, contains a variety of solid areas of color.

Quadrilateral on each source, we must construct a corresponding target quadrilateral to estimate the corrective homograph. The height and correction of the target quadrilateral source quadrilateral is the same height, uniform and accurate description of the texture size in the plane image after the correction, aspect ratio is estimated to determine the length of the target quadrilateral by formula (2). The location of the target quadrilateral can be estimated based on

the location of the plane image source quadrangle. In addition, the horizontal position of the target quadrilateral can be determined based on the width of the image quadrilateral vertical position and the height of the building to determine, as the buildings and land intersect $x = 0$, Figure 2 (b) shows a constructor accomplish quadrilateral source quadrilateral shown in Figure 2 (a)

Through a number of source quadrilateral and the target quadrilateral on four-point algorithm, it can use a number of corrective homograph deformation view and print images to face the diagram between the single four-point consistencies, which should be estimated as follows:

$$H = A^{-1} \cdot R \quad (3)$$

Where H is the homograph matrix A, R constructed by four o'clock with the consistency of three matrices can be written as follows:

$$H = \begin{bmatrix} h_{11} \\ h_{12} \\ h_{13} \\ h_{21} \\ h_{22} \\ h_{23} \\ h_{31} \\ h_{32} \end{bmatrix}, A = \begin{bmatrix} -x_1 & -y_1 & -1 & 0 & 0 & 0 & x'_1 & y'_1 \\ 0 & 0 & 0 & -x_1 & -y_1 & -1 & x'_1 & y'_1 \\ -x_2 & -y_2 & -1 & 0 & 0 & 0 & x'_2 & y'_2 \\ 0 & 0 & 0 & -x_2 & -y_2 & -1 & x'_2 & y'_2 \\ -x_3 & -y_3 & -1 & 0 & 0 & 0 & x'_3 & y'_3 \\ 0 & 0 & 0 & -x_3 & -y_3 & -1 & x'_3 & y'_3 \\ -x_4 & -y_4 & -1 & 0 & 0 & 0 & x'_4 & y'_4 \\ 0 & 0 & 0 & -x_4 & -y_4 & -1 & x'_4 & y'_4 \end{bmatrix}, R = \begin{bmatrix} x_1 \\ y_1 \\ x_2 \\ y_2 \\ x_3 \\ y_3 \\ x_4 \\ y_4 \end{bmatrix} \quad (4)$$

3×3 single matrix vector forms are described in the homography conditions, $h_{33}=1$, the four-point consistency $(x_i, y_i), (x'_i, y'_i), i=1 \dots 4$, can be seen as Figure 2, shows the source quadrilateral with the target quadrilateral four vertices

Introduction of errors due to feature extraction and feature processing, the location of the estimated source quadrangle contains the error, and therefore must be set to share, to choose the homograph in order to optimize the correction process, the top point of the building should be located in an ideal state number of horizontal lines in the image plane after the correction, the vertical boundary should be located in multiple vertical segments, and abnormal function is defined as:

$$J = \frac{1}{m} \sum_{i=1}^m abs\left(\frac{S_{T_i}}{S_{avg}}\right) + \frac{1}{n} \sum_{j=1}^n abs\left(\frac{ptx_j - pbx_j}{Dist_{avg}}\right) \quad (5)$$

Where m is the number of horizontal lines, n is the number of identified vertical boundaries, Slidirection of the horizontal lines after a correction, save the direction of the mean, ptx_j and

pbx_j the j th level of the corrected vertical boundary vertices coordinates,

$$abs\left(\frac{ptx_j - pbx_j}{Dist_{avg}}\right) \text{ horizontal direction}$$

method for the boundary vertices in the distance.

Formula (5) the right of the first part of said corrected the normal direction of the horizontal ideal state is 0, the second part refers to the distance from the direction of the vertices in the vertical direction of the upper boundary, and the ideal state is 0.

Ying Xing determined corresponding optimized single abnormal function of the minimize formula (5).

3.2 Color Correction

Color vertices of an RGB image color mapping model expressed as follows:

$$\begin{pmatrix} R \\ G \\ B \end{pmatrix} = w_d \begin{pmatrix} \beta_d^R s^R \\ \beta_d^G s^G \\ \beta_d^B s^B \end{pmatrix} + w_s \beta_s \begin{pmatrix} s^R \\ s^G \\ s^B \end{pmatrix} \quad (6)$$

First and second items, said diffuse reflectance and specula components, accordingly, w_d and w_s for the diffuse reflection and high-light weights, β_d and β_s for the diffuse reflection and high light items, of $(s^R, s^G, s^B)^T$ -expressed by chance light of RGB composition, lighting color by getting the formula (6) in $(s^R, s^G, s^B)^T$ to be estimated, assuming specula reflection has been ruled accidental light color component.

So that the RGB color space standardized color r, g as:

$$r = \frac{R}{R + G + B}, g = \frac{G}{R + G + B} \quad (7)$$

The same color domain contains the high-light reflection in the rg space to form a first (color line), when plotting more than one color domain, these lines in the rg space of a point of intersection, as shown in Figure 3, it is estimated that the light color as the point coordinates, you can get the linear equation (7) instead of (6).

$$g = a'r + b' \quad (8)$$

Such as formula (8) below, a 'and b' by occasional light (sR,sG,sB)T is defined, diffuse reflectance for the $(\beta_a^r, \beta_a^g, \beta_a^b)^T$, through the point (pr, pg) of each straight line as follows:

$$P_r = \frac{S_R}{S^R + S^G + S^B}, P_g = \frac{S^G}{S^R + S^G + S^B} \quad (9)$$

Where you can get (pr,pg) light color (sR,sG,sB)T by the formula (9) calculated.

In this paper, the color of the strong light reflection extracts the domain near the straight line, first of all, identify high-strength threshold reflection domain. On the image pixels of each color can get the nose of the changes in intensity of range color values, which based not only on the strength itself limited, but also the proportion. Therefore, the statistics along the direction of the high light intensity (left hand side under the side of the area), then choose n pixels outside the threshold region.

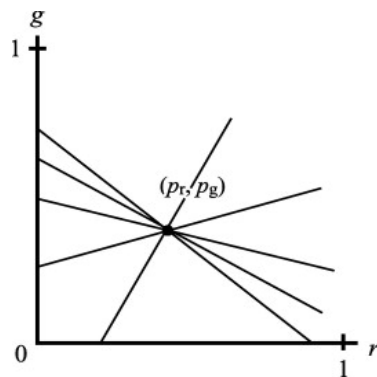


Figure 3. Intersection of Color Lines.

This article is calculated for each pixel and then an n-pixel color line by minimize the power method. Each of the regions of high light reflection of the color line, you can use the minimum power method to obtain intersection (pr, pg). Light color (sR,sG,sB)T the proportion of the ingredients through (pr,pg,1-pr-pg)T is given. Finally, the light color obtains compensation in this article; modify the colors by the following formula:

$$\begin{pmatrix} R_{new} \\ G_{new} \\ B_{new} \end{pmatrix} = \begin{pmatrix} \frac{P_g}{1 - P_r - P_g} R \\ P_r \\ G \\ \frac{P_g}{1 - P_r - P_g} B \end{pmatrix} \quad (10)$$

1. http://vpn.library.shmtu.edu.cn:2203/science?_ob=MathURL&method=retrieve&udi=B6WCX-4W

1JW58-1&_mathId=mml55&_user=2932517&_cdi=6750&_pii=S107731420900071X&_rdoc=15&_ArticleListID=1722979758&_issn=10773142&_acct=C000059226&_version=1&_userid=2932517&_md5=aff3ecaa653a77a3072c5cbc21c865e0

4. Texture Mapping

In this paper, the triangle is divided into many small area to deal with triangle, taking into account the block and photography-related issues, each of which can be seen a small area to determine the most reasonable color from the texture mapping. Combine the texture allocation strategy, the paper also take into consideration the structure of texture mapping and storage in order to show the model after the texture mapping.

4.1 Triangle normal's calculation

For improving the quality of the texture of each region, the calculation accuracy of the normal vector is intuitive and important. Normal vector should be as smooth as possible in order to reduce texture reconstruction in human factors, such as select different image in two adjacent areas due to drastic mutations. The strategies used in this article are presents as follows: First, each triangle shape of the normal vector to calculate the 3D position of the vertices of the triangle, and then calculated the average normal vectors of adjacent facets smooth normal vector of each triangle. Finally, by considering the average weighted normal vector triangle which is adjacent to the vertex of a triangle to calculate the normal vector of each vertex of the triangle. As shown in Figure 4.

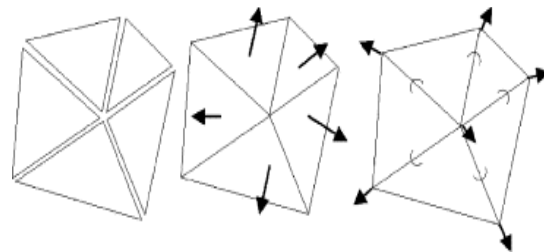


Figure 4. Complete model reconstruction (a) Image (b) Final model with texture http://vpn.library.shmtu.edu.cn:2203/science?_ob=ArticleURL&udi=B6WCX-50B5PTY-1&_user=2932517&_coverDate=02%2F28%2F2011&_alid=1721537527&_rdoc=1&_fmt=high&_orig=search&_origin=search&_zone=rslt_list_item&_cdi=6750&_sort=r&_st=13&_docanchor=&view=c&_ct=1176&_acct=C000059226&_version=1&_u

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To a normal vector for the small area of the triangle within the distribution Phong standard interpolation calculations, this method is sufficiently accurate for the purpose of this article, because the angle between the normal vectors is very small. This means that the small area found by linear interpolation of the vertex is decided by triangle normals .

4.2 Textures mapping texture mapping

In this section, first, analyze a given planar region with a color area sampling and optimization of the use of surface models of texture processing, the current issue of how the triangle is subdivided into a small area is sampled, the size of the triangle after treatment has been very similar, each side segments of the n segment to methodically sampled. So that each triangle has $n(n+1)/2$ small areas in order to determine the size of n , the first for each 3D triangle projection on the image, the triangle has the largest area, and then measuring the sides of and the number of pixels a triangle possess, and ultimately the average of these triangle edge's length.

The color of all the small area must be stored in standard computer graphics with texture mapping template of each triangle to the establishment of an $n \times n$ pixel matrix, then $n(n+1)/2$ a small region of color associated with these triangle to the upper left part of the triangle of the matrix. The triangular part of the affine transformation can be regarded as a 3D triangle texture, which this method, the longest side of arbitrary shape plane triangle is mapped to the upper right triangle of the diagonal, and then add into a single file which access to the entire texture mapping only by maternal, the same order and the order of the triangle in the data structure of these files

5. Experimental Results

Remodeling buildings through this method obtained a complete texture mapping as shown in Figure 5.

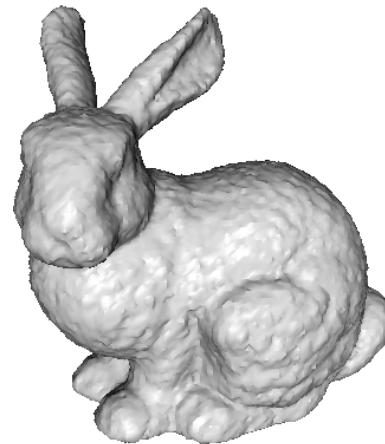


Figure 5. Complete reconstruction of the model (a) Image (b) has the texture of the final model

Texture sampling, through software or hardware texture mapping plane, the color of each sample point through its four weighted color acquisition near the pixel, which makes it appears the same as the diagonal of a matrix for each small area become necessary. Only to increase each diagonal by an additional single-pixel-wide border, the final decision of its color is decided by the small area is of adjacent triangles.

6. Conclusions

This paper presents a 3D reconstruction system, the building is redeveloped, you can use an automated method to perform a variety of treatment such as flat extraction, texture mapping and image correction, and these methods will eventually produce a certain degree of reconstruction quality. In this paper, these methods are adopted as automated processing steps to experimentally verify the results of the reconstruction for the entire automation system.

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