ICAT 2005 December 5-8, Christchurch, New Zealand

Mesh Based 3D Shape Deformation for Image Based Rendering from Uncalibrated Multiple Views

Satoshi Yaguchi Hideo Saito
Department of Information and Computer Science, Keio University
3-4-1 Hiyoshi, Kohoku-ku, Yokohama, 223-8522 JAPAN
{yagu, saito}@ozawa.ics.keio.ac.jp

Abstract

In this paper, we present a method to improve the quality of synthesized new view images for Image Based Rendering approach from uncalibrated multiple views targeting the detailed texture objects. To deform 3D model using the information such as image texture and object silhouette, the difference between the real object and the reconstructed model is evaluated as a function of optimization problem. The refined model provides a quite accurate dense corresponding relation between the images, so that high quality image can be synthesized at arbitrary viewpoint. We also demonstrate the proposed method by showing new view images rendered by the proposed method.

Key words: shape-from-silhouette, shape refinement, Image Based Rendering, uncalibrated mutltiple views

1. Introduction

Recently, the advanced approaches of the Visual Hull based new view image synthesizing method have intensively studied. The key issues of those approaches are to improve image quality with variant information derived from input images, because the differences between the reconstructed Visual Hull and the real object may cause blurring in the synthesized virtual images. The Space Curving Method [1] removes unnecessary voxels of the voxel-represented model using texture information by reducing difference between constructed model. The techniques for optimizing 3D model by deforming the vertex of surface triangle mesh based on the correlation of the texture have also been proposed [2][3].

The goal of our approach in this paper is to improve a quality of new view images deforming an initial 3D shape model for Image Based Rendering (IBR) from uncalibrated multiple views, which we have already proposed [4][5]. This method synthesizes using correspondence map derived from the model that is reconstructed with shape-from-silhouette method. Proposed method aims to reduce the blurring effect to deform the reconstructed model with the information such as image texture or object silhouette. Then quite accurate dense correspondence between the images derived from the refined model enables synthesizing high quality new view images without the blur.

2. Shape Refinement Algorithm

Our algorithm of deforming 3D shape is based on shifting a single vertex iteratively. Each vertex of reconstructed model is visited respectively and shifted independently. The process of shifting vertex position is performed by selecting and moving the candidate vertex to the point that maximizes evaluated value. To simplify the algorithm, the candidate points are defined in the line passing through the target vertex v_0 and a point *g* that is defined as the center of all adjacent vertexes. $2n+1$ candidate points (within the target vertex) are defined outside and inside of the model surface at intervals of a unit vector scaled by a weight *s*. *s* is decided dynamically depending on evaluation value of v_0 to enables to detailed search, and that is ranged $0.1 \leq s \leq 1.0$. Evaluated value V_n of candidate point v_n is calculated by the following equation (1).

$$V_n = \alpha \cdot V_{corr}(v_n) + \beta \cdot V_{smooth}(v_n) + \gamma \cdot V_{sil}(v_n) \quad (1)$$

V_{corr} : Texture correlation restriction
V_{smooth} : Smoothness Restriction
V_{sil} : Silhouette restriction

where α, β, γ are weighting terms.

2.1. Texture Correlation restriction

Texture correlation of vertex is determined by the texture of all adjacent triangle meshes. The correlations between each image are calculated by normalized cross correlation to apply all pixels of mesh. The correlation of v_n of adjacent mesh *k* between image *i* and image *j* is shown equation (2).

$$V_{corr_{kij}}(v_n) = \frac{\sum_p \left|(W_p - w) - (W'_{p'} - w')\right|}{\sqrt{\sum_p (W_p - w)^2 \sum_{p'} (W'_{p'} - w')^2}} \quad (2)$$

where W_p and $W'_{p'}$ are the color of the point *p*, *p'* and *w*, *w'* are the averages of color of meshes. And $V_{corr}(v_n)$ is decided by the average correlation of all adjacent meshes between each image.

ICAT 2005 Christchurch, New Zealand
ISBN 0-473-10657-4

2.2. Smoothness Restriction

Since the surface of the object should locally be smooth and continuous, the following smoothness restriction must be applied. In this proposed method targeting 3D object, smoothness restriction must be apply not plane but curvature filter. Then maximizing the smoothness terms results in the point of 1/6 of the segment v_0 to g. We apply following equation (3).

$$V_{smooth}(v_n) = \left(d(v_n) - d(v_0)/6\right)^2 \qquad (3)$$

where d is the distance between v_n and g. And weighting terms β will be negative.

2.3. Silhouette Restriction

The surface model after refined should be filled over the input visual hull sufficiently. Therefore the following silhouette restriction is applied to the initial target point and the candidate points. When v_0 is not projected onto the boundary of the silhouette on image i, $V_{sil\ i}$ is not defined, otherwise it is projected onto the boundary, $V_{sil\ i}$ is defined in proportion to the distance between v_n and v_0 If v_n is projected on outer silhouette even by one input image, it is excluded. After all, V_{sil} is defined by the sum of $V_{sil\ i}$ as following equation (4).

$$V_{sil}(v_n) = \sum_i V_{sil\ i}(v_n) = \sum_i d_i \qquad (4)$$

3. Experimental Result

The proposed method has been tested on real object. 36 images (640×480 pixels BMP format) were taken around target object. The target object was a paper craft of "Jaguar" of about 20×10×10cm. Figure 1 shows the input images and Figure 2 shows the new view images synthesized as interpolated ratio 5:5 of those input images. Although the model image without refinement (1) shows blurring in texture, the refined model image (2) is rendered sharpness without noted blur.

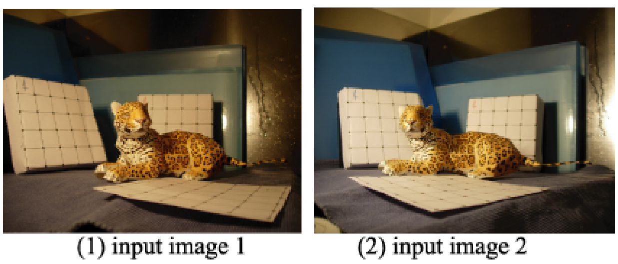

Figure 1. Sample of input images.

Figure 3 shows the comparison of texture of different iteration number: initial model (1), N=100 (3), N=300 (4), and real viewpoint image (2) that is taken from about same viewpoint as virtual viewpoints. It is observed that the quality of synthesized image has improved as the number of iterating process is increased and about the same quality texture is acquired from N=300 model (4).

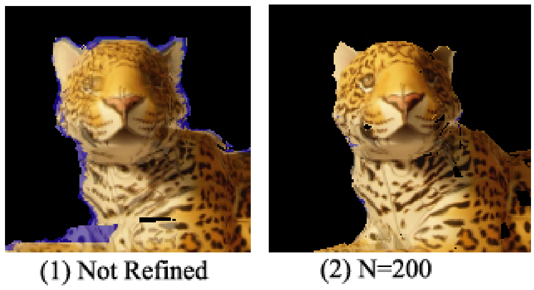

Figure 2 New view image from an initial model ((1)) and a refined model iterated with N=200 ((2)).

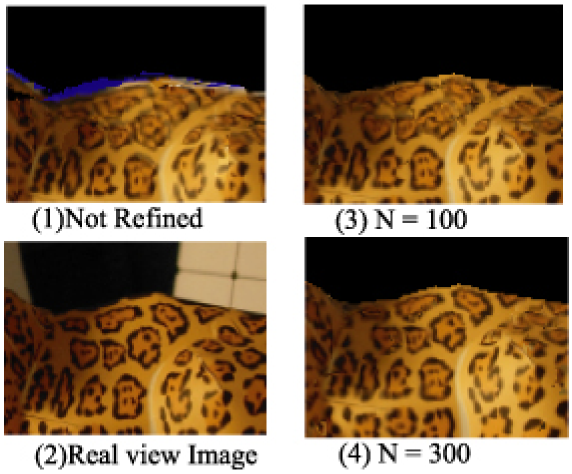

Figure 3. Comparision of textures.

4. Conclusion

We proposed a method for synthesizing high quality new view image with deforming the model. Deforming 3D shape model with the texture correlation and other restricts reduces the difference between the reconstructed model and the real object. Using refined model removes the blur on the image texture and enables synthesizing high quality free viewpoint image.

References

1. G.G.Slabaugh, R.W.Schafer, M.C.Hans, "Multiresolution space carving using level set methods, " Proc.ICIP02, Vol.II, pp.545-548, 2002.

2. G.Eckert, J.Wingbermuhle and W.Niem, "Mesh Based Shape Refinement for Reconstructing 3D-Objects from Multiple images, " The First European Conference on Visual Media Production (CVMP04), Mar.2004.

3. S.Nobuhara and T.Matsuyama, "Dynamic 3D Shape from Multi-Viewpoint Images using Deformable Mesh Models," Proc. of 3rd International Symposium on Image and Signal Processing and Analysis, Rome, Italy, September 18-20, 2003, pp. 192—197.

4. H. Saito and T. Kanade, "Shape Reconstruction in Projective Grid Space from Large Number of Images, " IEEE Proc. Computer Vision and Pattern Recognition, Vol. 2, pp. 49-54, 1999.

5. S. Yaguchi, H.Saito, "Arbitrary Viewpoint Video Synthesis from Multiple Uncalibrated Cameras, " IEEE Trans. on Systems, Man and Cybernetics, PartB, vol. 34, no1, PP.430-439, 2004.