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3D Face Surface Rendering by Pose Correction and Face Resurfacing

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Abstract-Face recognition in still images and video is widely used for many applications in computer vision and image processing. It is still a great challenge in biometrics research, because of the large variations of facial appearance, caused by head pose, lighting, facial expression, aging, illumination etc. Among all possible variations, the biggest challenge of facial appearance in two-dimensional face images probably comes from the head rotations in three dimensions. To tackle this case with depth map corrupted by pose variation and occlusions, we propose a resurfacing approach as a pre-processing stage. Here the pose correction is done by Iterative Closest Point (ICP) algorithm and reconstruction is done by patch cloning. Facial symmetry is used as the prior knowledge to supplement shape information in face techniques.

Index Terms- Face recognition; Face Resurfacing; Pose Correction; ICP algorithm; Patch Cloning

1. INTRODUCTION

Face recognition is important and useful for many applications, including homeland security, video surveillance, law enforcement, and identity management. Researchers have made significant progresses for face recognition in the biometric society. A number of face recognition methods have been developed with good performance. However it is still a great challenge for face recognition in practical applications, because of many variations of facial appearance, caused by head pose, facial expressions, illumination, aging etc.

The exploration of different face recognition technology is being analyzed in [1]. Face recognition is widely used for security at many places like airport, organizations, many devices etc. An approach for face recognition robust to head rotations utilizing the RGB-D face images is proposed in [4]. Traditional approaches have tried to tackle one challenge at a time using 2D images i.e. texture. The illumination cone method [6] models illumination changes linearly. They have shown that the set of all images of a face under the same pose but different illuminations lies on a low dimensional convex cone which can be learned from a few training images. Reference [10] focuses on extracting 3D or depth information using stereo matching for the purpose of enhancing face recognition. Researchers present a new fast stereo matching algorithm termed stereo cluster search (SCS) that can be performed in real time to generate depth information from the left and right stereo pair of a face image. Generating a 3D model using stereo vision can be achieved using two images captured by a stereo camera with two identical lenses separated horizontally or vertically

A pre-processing algorithm [5] is proposed which exploits the facial symmetry at the 3D point cloud level to obtain a canonical frontal view, shape and texture, of the faces irrespective of their initial pose. Reference [3] focuses on extracting 3D or depth information using stereo matching for the purpose of enhancing face recognition. Gee-Sern (Jison) Hsu proposed a resurfacing scheme [2] to handle the quantization noise. Due to the large distance between face and the RGB-D camera, the depth maps are corrupted by quantization noise. Here the resurfacing is done with the help of high resolution patches from another face. But in this case most of the failures are caused due to the difficulty to distinguish the resurfaced face since the resurfaced face loses some similarity to the actual face. So in our work, we are introducing a reconstruction technique which uses facial symmetry as prior knowledge.

2. PROPOSED METHOD

This paper includes a study of pose correction by ICP algorithm and face reconstruction using patch cloning method.

2.1. *Pose correction by ICP algorithm*

The face image with pose variations and occlusion at right half is considered as the synthetic image. Pose correction is done by Iterative Closest Point (ICP) algorithm. ICP is used to minimize the difference between the two point clouds.

The steps in ICP algorithm are:

- For each point in the probe point cloud, find the closest point in the reference point cloud.
- Calculate the combination of rotation and translation using a mean squared error function.
- This error function can be used for aligning the input point cloud to that of reference.
- Transform the points in the probe image using the obtained transformation.

The input and pose corrected output point clouds are then converted in to depth maps. Then the occlusions in the depth images and point clouds are reconstructed using a resurfacing technique called patch cloning.

2.2. *Face resurfacing by patch cloning*

This stage is required for the cases where the texture or depth image is deteriorated due to occlusions [9]. The approach replaces occluded depth patches by the corresponding depth patches from the symmetric part of the same face. It consists of the following steps:

- Resize the depth map of test face with that of the reference image.
- Detect the facial region which is corrupted due to occlusion. Correlation technique is used for this purpose.
- Find the corresponding face regions from the symmetric part.
- Replace the corrupted depth patches by the fine layered depth patches taken from the symmetric part of the test face.

3. EXPERIMENTS AND RESULTS

In our method, a multimodal database FRAV3D [7] is used. It consists of texture information (2D image), depth map (2.5D image) and VRML file (3D image). The texture image is in the form of RGB image and depth map is in the form of point cloud. It contains 100 persons with 16 samples per person at different pose variations.

From the frontal view of depth images, pose variation and occlusion are created. The resultant synthetic image is further used for the reconstruction. Fig. 1 gives an example of a synthetic image.

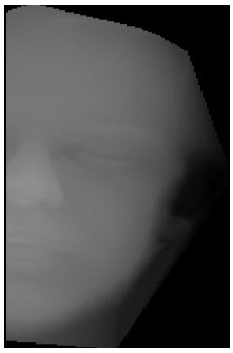


Fig. 1. Synthetic image

Pose correction is done by applying ICP algorithm on the point cloud of probe image. The reference point cloud should have a frontal pose. Pose corrected point cloud is shown in Fig. 2.

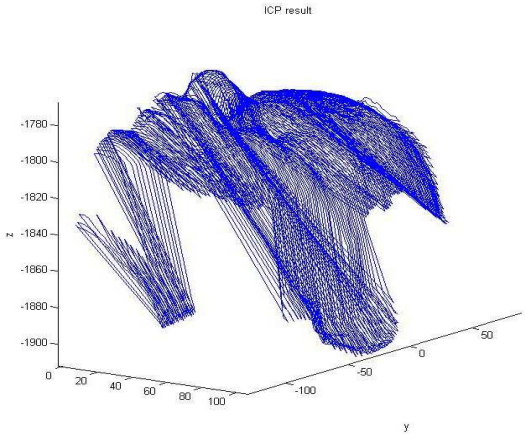


Fig. 2. Pose corrected point cloud

Now the point clouds are projected back to the depth maps. The corrupted patches are found by correlation method. The image used as the source image for correlation is shown in Fig. 3.

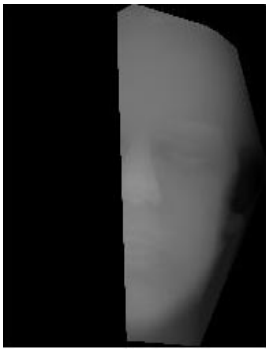
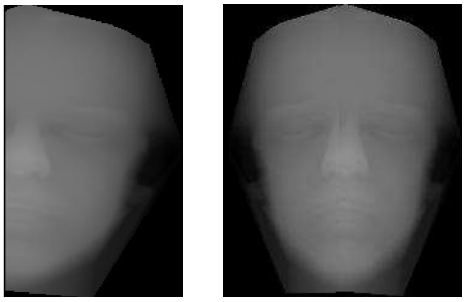


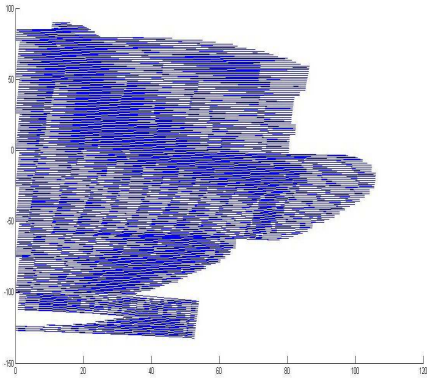
Fig. 3. Source image for the correlation

After creating the source image for correlation, the difference between this source image and reference is calculated using correlation method. From the output of correlation, the corrupted patches or parts of the face is calculated and these parts are replaced by the corresponding patches from the symmetric part of the same face itself by the resurfacing method called patch cloning. The depth map of actual face and the reconstructed face is shown in Fig. 4. Fig. 5 represents the point cloud of actual face and Fig. 6 represents the point cloud of reconstructed face in different views.

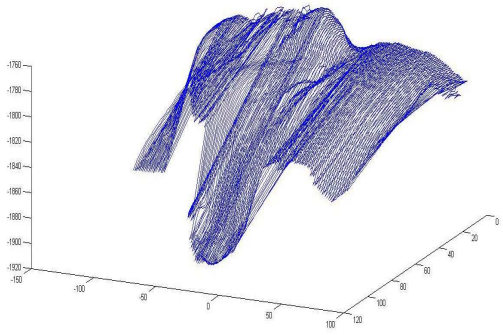


(a) (b)

Fig. 4. Depth map of (a) actual face (b) reconstructed face

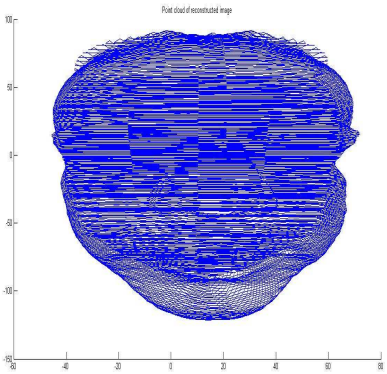


(a)

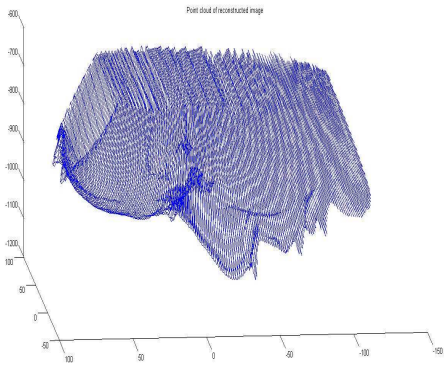


(b)

Fig. 5. Point cloud of actual face, (a) Frontal view, (b) side view



(a)



(b)

Fig. 6. Point cloud of reconstructed face, (a) frontal view, (b) side view

4. CONCLUSION

We propose a resurfacing method to handle the occlusion in depth map. The pose variations are corrected by ICP algorithm and it is followed by the resurfacing method. Resurfacing technique using patch cloning can also be done using the patches from an another face. But in that cases the failure rates are higher. Our approach uses facial symmetry as the prior information and the patches from the same face is taken so as to minimise the failure rate.

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