Chapter 29
3D Face Recognition using an Adaptive Non-Uniform Face Mesh

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ABSTRACT

Face recognition using 3D faces has become widely popular in the last few years due to its ability to overcome recognition problems encountered by 2D images. An important aspect to a 3D face recognition system is how to represent the 3D face image. In this chapter, it is proposed that the 3D face image be represented using adaptive non-uniform meshes which conform to the original range image. Basically, the range image is converted to meshes using the plane fitting method. Instead of using a mesh with uniform sized triangles, an adaptive non-uniform mesh was used instead to reduce the amount of points needed to represent the face. This is because some parts of the face have more contours than others, hence requires a finer mesh. The mesh created is then used for face recognition purposes, using Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA). Simulation results show that an adaptive non-uniform mesh is able to produce almost similar recognition rates compared to uniform meshes but with significant reduction in number of vertices.

INTRODUCTION

With the advancement of technology, face recognition using 3D images is slowly becoming a feasible option. This is because the ability to capture 3D images of faces accurately and efficiently is now becoming a reality. In the past, face recognition systems used 2D images to perform identification (Turk & Pentland, 1991; Belhumeur, Hespanha & Kriegman, 1997). Although 2D images can produce good results, they still suffer from a few problems, like illumination and pose changes (Zhao, Chellappa, Rosenfeld & Phillips, 2000).

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Since 3D images are able to overcome problems usually faced when using 2D images for face recognition, like illumination and pose changes, hence active research should be performed on face recognition using 3D images so that when the technology to capture 3D images efficiently finally arrives, the software to perform good recognition would also be ready.

An area that is worth investigating with regard to 3D face recognition is the representation of the 3D face image. At the moment, a common method to capture a 3D face image is to use a 3D scanner. Basically, the scanner will use either laser or light and shine onto the face, thereby obtaining a range image that consists of points with x, y and z coordinates. The x and y coordinate is the width and height of the point while the z coordinate represents the depth of that face point from the scanner. Therefore, the 3D image of the face from one direction is obtained.

Range image is able to represent the face accurately and has been used for 3D face recognition. They are able to show the exact contours of the face when the point matrix is dense enough. However, the image size can be huge due to the amount of data stored which takes up storage space or causes long transmission time. Besides that, some area of the face may not need a large amount of points to represent it, causing some points to be redundant.

Therefore, face meshes have been proposed in the past to represent a 3D face image for face recognition since they require fewer points. A mesh consists of many small polygons that make up the face. The advantage of using a face mesh is that each polygon represents a small area of a face. If the polygon used is a triangle, then a small area that may be represented by many data points in a range image can be represented by only 3 points in a mesh image. The points in a mesh are known as vertices while the lines joining the vertices are known as edges.

In this chapter, the aim is to create a mesh that is able to represent a face sufficiently for 3D face recognition while using minimum number of vertices. Hence, it is proposed that an adaptive non-uniform face mesh be built to represent the original face range image. This mesh will then be used for face recognition purposes to determine if the proposed face mesh is a feasible alternative.

BACKGROUND

A typical mesh consists of many uniform little triangles that cover the whole face, as shown in Figure 1. (Xu et al., 2004) method converts a point cloud face into a mesh, first by using a coarse mesh and then subsequently refining it to a finer dense mesh to represent a face. After that, recognition is done using the face meshes. Although recognition usually concentrates on the face area around the eyes, nose and mouth, the whole face was converted into a finer dense mesh for recognition.

(Ansari et al., 2007) used a general mesh model of a face and deformed this model according to the range image of the face, estimating the depth of the triangles using plane fitting. To obtain a smoother mesh, they subdivide each triangle into 4 smaller triangles and then deform the mesh again using plane fitting to get a more accurate mesh for the face. After that, recognition is performed using a voting-based classifier. However, the criteria to determine whether the mesh is accurate enough for the face were not discussed.

(Tanaka et al., 1993) also performed subdivision on their triangles. However, they only divided their mesh triangle into 2 triangles instead of 4. The meshes were subdivided according to their surface curvature and will only stop the subdivision at a certain predetermined threshold.

(Wu et al., 2001) proposed a geometric mesh simplification scheme for constructing multi-resolution meshes. Using the Face Constriction Process (FCP), they introduce a mesh simplification scheme that was also effective in preserving the face features. This was achieved by using the

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