3D Facial Recognition with Soft Computing

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Abstract. The depth information in the face represents personal features in detail. In particular, the surface curvatures extracted from the face contain the most important personal facial information. These surface curvature and eigenface, which reduce the data dimensions with less degradation of original information, are collaborated into the proposed 3D face recognition algorithm. The principal components represent the local facial characteristics without loss of the information. Recognition for the eigenface referred from the maximum and minimum curvatures is performed. The normalized facial images are also considered to enhance the recognition rate. To classify the faces, the cascade architectures of fuzzy neural networks, which can guarantee a high recognition rate as well as parsimonious knowledge base, are considered. Experimental results on a 46 persons data set of 3D images demonstrate the effectiveness of the proposed method.

Keywords: 3D Face, Fuzzy Neural Networks.

1 Introduction

Today’s computer environments are changing because of the development of intelligent interface and multimedia. To recognize the user automatically, research has been conducted on various recognition methods using biometric information – fingerprint, face, iris, voice, vein, etc [1]. In a biometric identification system, face recognition is a challenging area of research, along with fingerprinting, because it uses a no-touch style. For visible spectrum imaging, there has been many studies reported in literature [2]. However, the method has been found to be limited in its application. It is influenced by lighting illuminance, and encounters difficulties when the face is angled away from the camera. These factors cause low recognition. To solve these problems a computer company has developed a 3D face recognition system [2][3]. To obtain a 3D face, this method uses stereo matching, laser scanner, etc. Stereo matching extracts 3D information from the disparity of 2 pictures which are taken by 2 cameras.
Even though it can extract 3D information from near and far away, it has many difficulties in practical use because of its low precision. 3D laser scanners extract more accurate depth information about the face, and because it uses a filter and a laser, it has the advantage of not being influenced by the lighting illuminance when it is angled away from the camera. A laser scanner can measure the distance; therefore, a 3D face image can be reduced by a scaling effect that is caused by the distance between the face and the camera [4][5].

Broadly speaking, the two ways to establish recognition employs the face feature-based approach and the area-based approach [5-8]. A feature-based approach uses feature vectors that are extracted from within the image as a recognition parameter. An area-based approach extracts a special area from the face and recognizes it using the relationship and minimum sum of the squared difference. Face recognition research usually involves 2D images. Recently, the 3D system has become cheaper, smaller and faster to process. Thus the use of 3D face image is now becoming more readily researched [3][9-12]. Many researchers have used 3D face recognition using differential geometry tools for the computation of curvature [9]. Hiromi et al. [10] treated 3D shape recognition problem of rigid free-form surfaces. Each face in the input images and model database is represented as an Extended Gaussian Image (EGI), constructed by mapping principal curvatures and their directions. Gordon [11] presented a study of face recognition based on depth and curvature features. To find face specific descriptors, he used the curvatures of the face. Comparison of the two faces was made based on the relationship between the spacing of the features. Lee and Milios [13] extracted the convex regions of the face by segmenting the range of the images based on the sign of the mean and Gaussian curvature at each point. For each of these convex regions, the Extended Gaussian Image (EGI) was extracted and then used to match the facial features of the two face images.

One of the most successful techniques of face recognition as statistical method is principal component analysis (PCA), and specifically, eigenfaces [14][15]. In this paper, we introduce novel face recognition for eigenfaces using the curvature that well presents personal characteristics and reduces dimensional spaces. Moreover, the normalized facial images are considered to improve the recognition rate.

Neural networks (NNs) have been successfully applied to face recognition problems [16]. However, the complexity of the NNs increases exponentially with the parameter values, i.e. input number, output number, hidden neuron number, etc., and becomes unmanageable [17]. To overcome this curse of dimensionality, the cascade architectures of fuzzy neural networks (CAFNNs), constructed by the memetic algorithms (hybrid genetic algorithms) [18], are applied.

2 Face Normalization

The nose is a protruded shape located in the middle of the face. So that it may be used as the reference point, first we attempted to find the nose tip using the iterative selection method after extraction of the face from the 3D face image [19]. Usually, face recognition systems suffer from drastic losses in performance when the face is not correctly oriented. The normalization process proposed here is a sequential procedure that aims to put the face shapes in a standard spatial position. The processing sequence includes panning, rotation and tilting [20].