Image Preprocessing Methods in Face Recognition

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***Abstract*—Face recognition is being studied as a hot topic research in pattern recognition. The method of PCA is usually used in face recognition for extracting features, but it is easily affected by light condition and facial expression changed and other reasons. So before extracting features we can preprocess face images to improve the face recognition rate. This paper introduces some preprocessing methods in face recognition. Firstly, we present an overview of face recognition and its applications. Then several methods of preprocessing methods are introduced. At last, conclusions are given.**

Keywords—Face recognition; PCA; Wavelet transform; DCT;

I. INTRODUCTION

Face recognition is an important research problem which spans numerous fields and disciplines. Not only the computer science researchers, but also the psychologists and neuroscientists are involved in this area. The reason is that face recognition, in additional to having numerous practical applications such as bankcard identification, access control, Mug shots searching, security monitoring, and surveillance system, is a fundamental human behavior that is essential for effective communications and interactions among people[1].

A face image is easily subjected to changes in viewpoint, illumination, and expression and so on. So the first issue is what features can be used to represent a face in order to be able to deal with possible changes and expression. Therefore, some preprocessing methods should be used in order to reduce these affections to some extent.

Preprocessing images is of vital importance in facer recognition. Using a good method of preprocessing can improve the face recognition rate.

II. IMAGE PREPROCESSING METHODS

In this section some preprocessing methods are introduced to preprocess face images before extracting features.

A Wavelet Transform

Wavelet transform technique is a new field in face recognition and it has an impact on some old and new disciplines. Compared with Fourier transform and Gabor transform, it can extract useful information effectively. Thus, it can solve some problems that Fourier transform can not resolve. Wavelet transform provides a powerful and versatile framework for image processing. It is widely used in the fields of image de-noising, compression, fusion, and so on. The changes of expressions in the sample images of an individual result in the differences of higher frequency band of the images. The basic functions of wavelet transform are obtained from a single prototype wavelet (or mother wavelet) by translation and dilation [2]:

$$\psi_{a,b}(t) = \frac{1}{\sqrt{a}}\psi(\frac{t-b}{a}) \qquad (1)$$

Where a and b are both real numbers which quantify the scaling and translation operations. Substitute a and b with 2m and n×2m respectively, the basic functions become

$$\psi_{a,b}(t) = 2^{-m/2}\psi(2^{-m}t-n) \qquad (2)$$

The process of one-dimensional discrete wavelet transform and reconstruction a signal x (t) is defined as follows:

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$$W(m,n) = < x(t), \Psi_{m,n}(t) > \qquad (3)$$

$$\chi(t) = \sum_{m,n} W(m,n) \bar{\Psi}_{m,n}(t) \qquad (4)$$

The two-dimensional wavelet transform is got by applying one-dimensional wavelet transform to the rows and columns of two-dimensional data. An approximation image is derived from 1-level wavelet decomposition of an image and three detail images in horizontal, vertical and diagonal directions respectively. The approximation image is used for the next level of decomposition

Figure 1 is the process of decomposing an image, Figure2 is an image from ORL Face Database, Figure 3 is obtained after one-level wavelet transform.

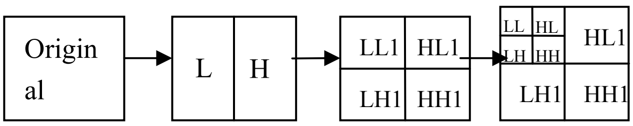

Figure1. The process of decomposing an image

Figure2. Original image

Figure3.one-levelwavelet transform

B. Discrete CosineTtransform

In the past two decades, there have been a variety of studies on the distributions of the discrete cosine transform (DCT) coefficients for images [3]. Like other transforms, the Discrete Cosine Transform (DCT) makes an attempt to decorrelate the image data. After decorrelation each transform coefficient can be encoded independently, but there is no compression efficiency lost.

The most common DCT definition of a One-Dimensional DCT sequence of length N is

$$C(u) = \partial(u) \sum_{x=0}^{N-1} f(x) \cos[\frac{\pi(2x+1)u}{2N}] \qquad (5)$$

for u = 0,1,2,⋯,N −1.

The Two-Dimensional DCT is a direct extension of the 1-D case and is given by

$$C(u,v) = \partial(u)\partial(v) \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} f(x) \cos[\frac{\pi(2x+1)u}{2N}] \cos[\frac{\pi(2x+1)v}{2N}] \qquad (6)$$

In both equations (6) and (7), $\partial(u)$ and $\partial(v)$ can be defined as

$$\partial(u), \partial(v) = \begin{cases} \sqrt{\frac{1}{N}} & u,v = 0 \\ \sqrt{\frac{2}{N}} & u,v \neq 0 \end{cases} \qquad (7)$$

Figure4 is an image after DCT transform from Figure2

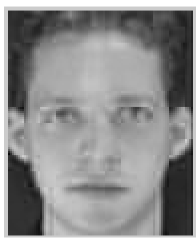

Figure4. An image after DCT transforms

C. Color Normalization Methods

Color normalization methods mainly include intensity normalization, gray world normalization, comprehensive color image normalization, and standard definition of hue [4]. Let us shortly introduce them respectively.

1) Intensity normalization: A well-known image intensity normalization method is applied here, and we can assume that, for the intensity of the lighting source is increased by a factor, in the image each RGB component of each pixel is scaled by the same factor. We can divide by the sum of the three color components to remove the effect.

$$(r_{norm}, g_{norm}, b_{norm}) = (\frac{r}{r+g+b}, \frac{g}{r+g+b}, \frac{b}{r+g+b}) \quad (8)$$

2) Gray world normalization: Here we take an approach which is similar to the above normalization, but compensate for the effect of variations in the color of the light source. The RGB color components of an image can be caused by different colors of light cause to scale apart, by factors α, β and γ respectively.

3) Comprehensive color image normalization: We apply an algorithm which is proposed by Finlayson [5], and it normalizes an image for variations in both lighting geometry and illumination color. The method involves the repetition of intensity normalization followed by grey world normalization (as described above), until the resulting image reaches a stable state.

4) Standard definition of hue: The hue of an image can be calculated by using the standard hue definition, such as each pixel is represented by a single scalar value *H*.

$$H = \cos^{-1}(\frac{\frac{1}{2}[(r-g)+(r-b)]}{\sqrt{(r-g)(r-g)+(r-b)(g-b)}}) \quad (9)$$

5) Statistical methods: Statistical methods mainly include brightness, horizontal brightness, vertical brightness, local brightness and local brightness mean. These statistical methods apply transformations to the image intensity values so as to make the brightness and contrast constant for all images. The effect is that the brightness of every image appears to be equal. These statistical methods can be applied in many ways, mainly by varying the areas of the image where the statistics are gathered. It is not necessary that lighting conditions will be the same at all points on the face, as the face itself can cast shadows. Therefore, in order to compensate for the variations in lighting conditions across a single face, these methods can be applied to individual regions of the face. This means that, we are not only compensating for a difference in lighting conditions from one image to another, but also for different lighting conditions from one area of the face to another.

III. AN INTRODUCIION TO THE ORL DATABASE OF FACES

In this section, we will briefly introduce the ORL database of faces which is usually used in face recognition.

This database contains a set of face images which was taken between April 1992 and April 1994 at the lab. The database was used in the context of a face recognition project carried out in collaboration with the Speech, Vision and Robotics Group of the Cambridge University Engineering Department [6].

There are forty persons in the database, and for each person they are ten images. For some subjects, the images were taken at different times, with the lighting, facial expressions (open / closed eyes, smiling / not smiling) varying and facial details (glasses / no glasses). All the images were taken against a dark homogeneous background with the subjects in an upright, frontal position (with tolerance for some side movement).

Figure5.Some images from The ORL Database of Faces

IV. CONCLUSIONS

In this paper, we shortly introduce some image preprocessing methods used in face recognition. The performance of PCA method is highly dependant on the image capture conditions and it is easily affected by Variations in lighting conditions, differences in pose, and image quality and so on, so it is necessary to preprocess these face images to improve the face recognition rate. Most of the time, we often combine two or more preprocessing methods so as to achieve a better result.

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