Face Recognition System Based on Template Matching in Frequency Domain",

Conference Paper · March 2013

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Abstract—**This paper presents a new approach for face recognition system based on template matching in frequency domain. The idea of using template matching is to design a specific Minimum Average correlation energy filter (MACE). The proposed recognition technique is performed by a cross correlation between the input images and the designed filter. The technique is applied on the ORL database which consists of more than 400 face images. The experimental results show that this technique is powerful and improve the recognition accuracy.**

Keywords-component; templete matching; DFT; MACE Filter; Correlation; ORL

I. INTRODUCTION

Face recognition task is becoming required more frequently in the modern world because it is widely used in interactive user interfaces, in advertisement industry, entertainment services, video coding, etc. Face Recognition can be defined as a problem of identifying or verifying a person from still images or video sequences using a stored database of facial images [1, 5]. Usually, the input to a face recognition system is an unknown face; in identification problems, the system retrieves the identity of the input face from the database of known individuals; whereas in verification problems the system either accepts or rejects the claimed identity of the query face. Face recognition techniques can be divided into two categories, depending upon the type of images (still or video) being used in the recognition system. Our work is confined to recognition of face from still images only. Usually, the available images are 2D intensity mages of human faces. A fully automatic face recognition system must perform the following three subtasks: face detection, feature extraction and recognition/ identification. However, each of these subtasks is a separate area of research and concentrating on all of them simultaneously is difficult [1]. Isolating the subtask not only simplify our job but also enhance the assessment and advancement of the component techniques. So, instead of detecting faces from images, standard databases of faces have been used for the experiments; and our prime focus has been developing a new efficient feature extraction technique.

The aim of this paper is to design a face recognition algorithm. The designed algorithm is divided into three parts. The first part is to train images selected from the ORL database [7] for synthesizing the template filter. The second part utilizes the cross–correlation between the tested image and the synthesized filter. The last part is to make classification and to give the final decision of rejecting or accepting this image. We typically seek to obtain correlation outputs with sharp correlation peaks in order to simplify detection.

II. FILTERING IN FREQUENCY DOMAIN

The Fourier transform is important in mathematics, engineering, and the physical sciences. Its discrete counterpart is the Discrete Fourier Transform (DFT),

$$F[k,l] = \sum_{n=0}^{N-1}\sum_{m=0}^{M-1} f[m,n] e^{-j2\pi(\frac{mk}{M}+\frac{nl}{N})} \quad \dots (1)$$

$$(0 \le m,k \le M-1, \quad 0 \le n,l \le N-1$$

The inverse of DFT:

$$f[m,n] = \frac{1}{MN}\sum_{l=0}^{N-1}\sum_{k=0}^{M-1} F[k,l] e^{j2\pi(\frac{mk}{M}+\frac{nl}{N})} \quad \dots (2)$$

Where MN is image size, $f[m,n]$ are image's pixels, $F[k,l]$ are coeffecients of Fourier transform, N is number columns, and M is number of rows. DFT is normally computed using the so-called Fast Fourier Transform (FFT) [2]. Using Fourier transform, it has been possible to analyze an image as a set of spatial sinusoids in various directions. Each sinusoid has a precise frequency. We designed the proposed filter in frequency domain as it will be discussed later.

III. MINIMUM AVERAGE CORRELATION ENERGY FILTER

The main idea of Minimum Average correlation energy filter (MACE) filter is to synthesize a filter using a set of training images that would produce correlation output. The filter's function is to increase the peak sharpness by minimizing the average correlation energy over a set of training images, whilst constraining the correlation peak height at the origin to a user-defined value. This in turn produces sharp peaks at the origin of the correlation plane, whilst producing values close to zero over the rest of the plane. The optimal solution to the MACE filter H is found using Lagrange multipliers, which provides the local maxima and minima of a function subject to equality constraints, in the frequency domain and is given by.

$$H = D^{-1}X(X^{*}D^{-1}X)^{-1}u \quad \dots (3)$$

D is a diagonal matrix of size d×d, and d is the number of pixels in the image (We used 48x48 pixels) containing the average correlation energies of the training images across its diagonals. X is a matrix of size N×d where N is the number of training images, and X^* is the complex conjugate of X. The columns of the matrix X represent the Discrete Fourier coefficients for a particular training image Xn. The column vector u of size N contains the correlation peak constraint values for a series of training images. The column vector **u** contains N entries, corresponding to desired values at the origin of the correlation plane of the training images. These constraint values are typically set to 1 for all training images from the authentic class.

IV. CORRELATION FILTERS

Correlation is a natural metric for characterizing the similarity between a reference pattern r(x, y) and a test pattern t(x, y) [3-4].

$$c(Tx,Ty) = \iint t(x,y)r(x-Tx, y-Ty)dxdy \quad (4)$$

In this study, the reference pattern is the synthesized filter (template) and the test pattern is a test image. The correlation plane is gauged with a performance metric in conjunction with a threshold, Then it makes sense to select its maximum as a metric of the similarity between the two patterns and the location of the correlation peak as the estimated shift of one pattern with respect to the other. The correlation output is searched for the peak, which is used to determine whether the object of interest is present or not (authentic output or imposter output)

V. METHODOLOGY

In the case of face verification we want only the face images belonging to the authentic class to produce such sharp peaks. We can summarize our work in six steps.

1. Multiply the input image by $\mathbf{(-1)^{x+y}}$ to center the transform.
2. Compute F (u, v), the DFT of the image from (1).
3. Multiply F (u, v) by a filter function H (u, v).
4. Compute the inverse DFT of the result in (3).
5. Obtain the real part of the result in (4).
6. Multiply the result in (5) by $\mathbf{(-1)^{x+y}}$.

We will show in fact that this is the case in our experiments with synthesized MACE filter. Minimum Average correlation energy filter is synthesized template from multiple training images, and then the filter optimizes a criterion to produce a desired correlation output plane. In previous researches, the peak-to-side-lobe ratio (PSR), illustrated is in equation (5), has been used as a benchmark for correlation plane quantification.

$$PSR = \frac{peak - mean}{\sigma} \quad \ldots \quad (5)$$

Where, peak is the maximum peak value in the correlation plane, mean is the average of the side lobe region, and σ is the standard deviation of the side lobe region values [6]. In this study, we use maximum peak value for measuring correlation planes. The maximum peak value is taken as the maximum correlation peak value over a correlation plane. So the correlation plane that has sharp peak value, authentic output, indicates that the tested image is matched; whereas, the imposter output shows that the tested image is not matched.

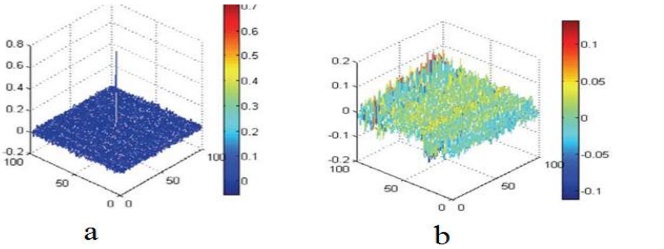

Figure 1: (a) Authentic output-Matched. (b) Imposter output-Not Matched

The left correlation output in figure.1 shows a sharp correlation output resulting from cross-correlating the filter with a test image from the authentic class, and the right image shows a correlation output resulting from a impostor face image. Notice that there is no discernible peak visible in the impostor output.

The block diagram of our algorithm is shown in figure.2, where the cross-correlation obtained using Discrete Fourier Transform (DFT) implementation. The filter output should give high peak value at the origin of the correlation plane when the input face image is from true class.

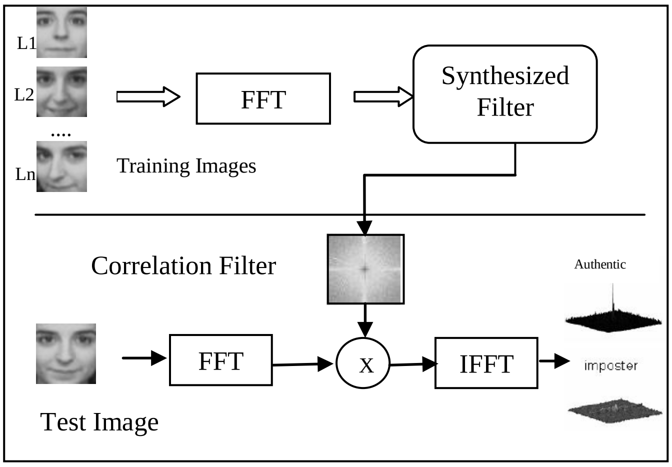

Figure 2 Block Diagram of Face Recognition

VI. EXPERIMENTAL RESULT

The database used in this work is part of the ORL database (Olivetti Research Lab). It contains slight variations in illumination, facial expression (open/closed eyes, smiling/not smiling) and facial details (glasses/no glasses). The ORL database consists of 400 face images, 10 images for each personal, the standard resolution of ORL database is (112*92).

The resolution of the database that has been used in this system is (48*48). Figure 3 shows the sample of the ORL database[7].

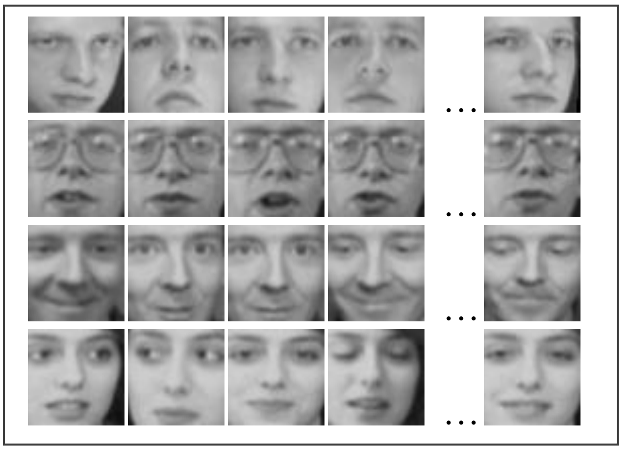

Figure. 3 . Samples from ORL database

variable number of the training images for designing the filter for special class will be used. For example, three training images of any personal are used, and then the results can be obtained from cross-correlation between the tested image and synthesized filter. If the image is in the same class, the same person, the output will be very sharp as shown in figure 4.

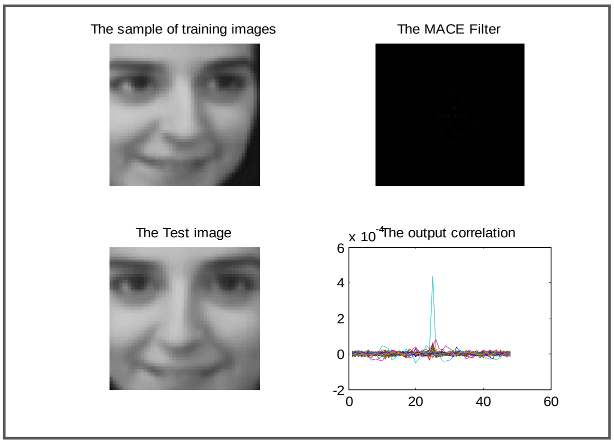

Figure 4 Authentic output-Matched

In the other hand, if the image is not in the same class, different person, the output will not be sharp as shown in figure5.

In order to measure the sufficiency of our technique, we use the recognition rate which can be calculated by following equation:

$$Recognition\ Rate = \frac{Number\ of\ identified\ faces}{number\ of\ all\ faces} \times 100$$

Using the recognition rate as an evaluation method, we run the algorithm on all images in ORL database as shown in Table.I.

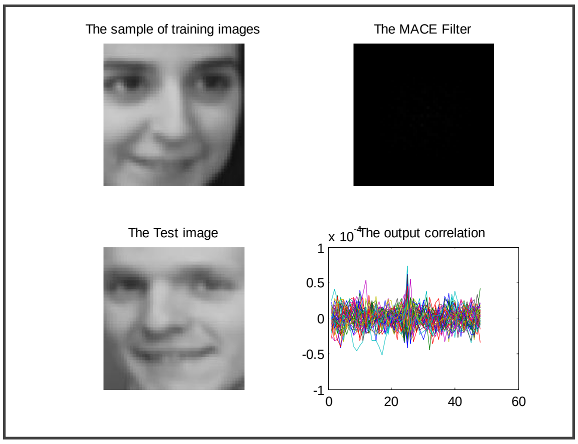

Figure 5 Imposter output-Not Matched

Let the number of training images = 3

If the number of the selected test image from the class is 10, then the following table will shows the recognition rate of designed system as shown in the following table (Yes= sharpen peak, No=not sharpen peak). This also presented graphically in Figure 6

TABLE I. RECOGNITION RATE

Class	1	2	3	4	5	6	7	8	9	10	rate
S1	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	No	60
S2	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	90
S3	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	90
S4	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	80
S5	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	80
S6	Yes	Yes	Yes	yes	No	Yes	No	Yes	No	No	60
S7	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	70
S8	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	No	60
S9	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	90
S10	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	No	60

Each column in figure 6 represents the recognition rate of the specific image. As can be seen, the recognition rate is in range between 60 % and 90%.

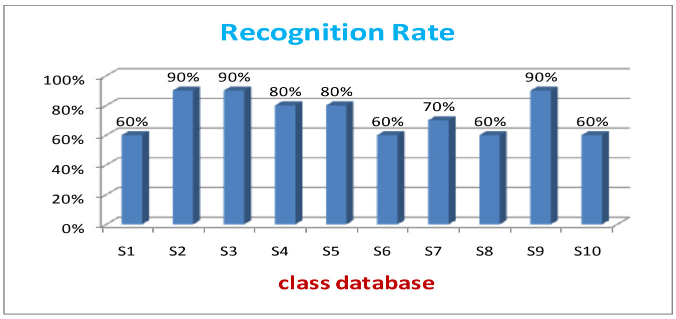

Figure 6. Recognition Rate vs. the class of database

VII. CONCLUSION

This paper presented approach for face recognition system based on template matching in frequency domain. The template matching works here as filter for extraction the selected frequency by Fourier transform. We presented experimental results for face recognition taken from Olivetti Research Lab (ORL) database. We first synthesize the MACE filter using a set of training images that would produce correlation output. This filter is correlated with the unknown face. The correlation output is searched for the peak, which is used to determine whether the face is matched the designed filter or not (authentic output or imposter output). We tested the algorithm on 400 face images, 10 images for each personal. The experimental results shown in figure 6 that compare between the recognition rate and class of database.

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