ISSN 2320-9984

Volume 1, Issue 3, October 2013 ISSN: 2320-9984 (Online)

International Journal of Modern Engineering & Management Research

Website: www.ijmemr.org

Quality Vector Based - Face Recognition

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Abstract—*The traditional matrix-based feature extraction methods that have been widely used in face recognition. The efficient management and combination of uncertain and conflicting sources of information are of great importance for the development of reliable information fusion systems. Biometric fusion consolidates the output of multiple biometric classifiers to make a decision about the identity of an individual. In this paper, a dynamic selection algorithm is designed to optimize both verification accuracy and computational cost. The proposed algorithm unifies the constituent classifiers and fusion schemes. In this method, a novel score-level fusion strategy based on quality measures for multimodal bio-metric authentication is presented and the fusion function is adapted every time.*

Keywords—*face verification, fusion, PCA, LDA*

1. INTRODUCTION

Face recognition presents a challenging problem in the field of image analysis and computer vision, and as such has received a great deal of attention over the last few years because of its many applications in various domains. It has been well established that a carefully designed match score fusion algorithm can improve the performance of a multi biometric system. Face recognition techniques can be broadly divided into three categories based on the face data acquisition methodology: methods that operate on intensity images; those that deal with video sequences; and those that require other sensory data such as 3D information or infra-red imagery.

A major problem with existing match score fusion algorithms occurs when different classifiers generate conflicting results on the same input biometric data. The issue can be described as follows: Given facial images with different expressions, how could we devise an algorithm which robustly identifies a person’s face?

There are different schemes for performing score level fusion based on different models. These include density-based fusion schemes where the model is based on estimating density functions for the genuine and impostor score distributions; transformation-based fusion schemes where the model is based on estimating normalization functions; and classifier-based fusion schemes where the model is a classifier.

While match score fusion has been demonstrated to be effective [6], [9], its matching performance is compromised under several scenarios.

Density-based score fusion schemes [6] which use the like-hood ratio test to formulate the fusion rule can be affected by the use of incorrect density functions for the genuine and impostor scores. The use of parametric methods of density estimation can be based on the assumption of incorrect models (e.g., Gaussian densities for both genuine and impostor scores) that can lead to suboptimal fusion rules; the use of nonparametric methods, on the other hand, is affected by the availability of a small number of training samples (especially genuine scores) thereby impacting the feasibility of designing an effective fusion rule.

Classifier-based fusion schemes [8] are susceptible to overtraining on one hand and classifier bias on the other [13], [10]. Further, a pure data-driven approach will not be able to accommodate scenarios that are not represented in the training data. For example, when conflicting scores from multiple matchers are presented to the fusion classifier, then, in the absence of sufficient training samples representing such a scenario, an incorrect decision may be regularly rendered.

One way to improve the verification accuracy, without increasing the computational cost, is to develop a context switching scheme that dynamically selects the most appropriate classifier or fusion algorithm for the given image. The second contribution of this work is the design of an algorithm for the dynamic selection of constituent unimodal biometric classifiers or matches score fusion algorithms that not only improve the verification accuracy but also decrease the computational cost of the system.

We propose a sequential fusion algorithm which combines a density-based fusion scheme with a classifier-based scheme. The first contribution lies in using a support vector machine (SVM) classifier in conjunction with the likelihood ratio test statistic.

The performance of the proposed algorithm is evaluated in the context of a face recognition application to mitigate the effect of covariate factors such as pose, expression, illumination, and occlusion. Match scores computed from two face recognition algorithms, namely local binary pattern (LBF) [13] and neural network architecture-based 2-D log polar Gabor transform (2DG-NN) [20], are fused and the verification performance is compared with existing match score fusion algorithms. Experiments indicate that the proposed fusion architecture efficiently improves the verification performance without increasing the computational cost.

This paper presents a method for fusion algorithm to address these challenges and improve the verification performance of a multi biometric system. Image fusion provides the means to integrate multiple images into a composite image that is more suitable for the purposes of human visual perception and computer-processing tasks such as segmentation, feature extraction and target recognition.

The organization of the paper is as follows. After a general introduction of the face recognition system, different image fusion techniques are discussed in section 2. The proposed selection algorithm is described in section 3. To evaluate the performance of the proposed method 250 different images are considered in section 4 and finally paper has been concluded in section 5.

2. IMAGE FUSION TECHNIQUES

The process of image fusion the good information from each of the given images is fused together to form a resultant image whose quality is superior to any of the input images. Image fusion method can be broadly classified into two groups –1. Spatial domain fusion method. 2. Transform domain fusion. In spatial domain techniques, we directly deal with the image pixels. The pixel values are manipulated to achieve desired result. In frequency domain methods the image is first transferred in to frequency domain. It means that the Fourier Transform of the image is computed first. All the Fusion operations are performed on the Fourier transform of the image and then the Inverse Fourier transform is performed to get the resultant image. Image Fusion applied in every field where images are ought to be analyzed. For example, medical image analysis, microscopic imaging, analysis of images from satellite, remote sensing Application, computer vision, robotics etc [11] [2]. The fusion methods such as averaging, Brovey method, principal component analysis (PCA)[15] and IHS based methods fall under spatial domain approaches.

Spatial distortion can be very well handled by frequency domain approaches on image fusion. The multi resolution analysis has become a very useful tool for analyzing remote sensing images. The discrete wavelet transform has become a very useful tool for fusion. Some other fusion methods are also there such as Laplacian- pyramid based, Curvelet transform based etc. These methods show a better performance in spatial and spectral quality of the fused image compared to other spatial methods of fusion [9]

Image Fusion Algorithms

In this section we discuss the set of image fusion algorithms [3][4] we considered, categorizing them under two subsections

The limited focus depth of the optical lens it is often not possible to get an image that contains all relevant objects in focus. To obtain an image with every object in focus a multi-focus image fusion process is required to fuse the images giving a better view for human or machine perception. Pixel-based, region-based and wavelet based fusion algorithms were implemented [1].

The trivial image fusion techniques mainly perform a very basic operation like pixel selection, addition, subtraction or averaging. These methods are not always effective but are at times critical based on the kind of image under consideration.

a.i Average Method

It is a well documented fact that regions of images that are in focus tend to be of higher pixel intensity. Thus this algorithm is a simple way of obtaining an output image with all regions in focus. The value of the pixel P (i, j) of each image is taken and added. This sum is then divided by 2 to obtain the average. The average value is assigned to the corresponding pixel of the output image which is given in equation (1). This is repeated for all pixel values.

$$K(i, j) = \{X(i, j) + Y(i, j)\}/2 \quad \ldots\ldots(1)$$

Where X (i, j) and Y (i, j) are two input images.

a.ii Select Maximum:

The greater the pixel values the more in focus the image. Thus this algorithm chooses the in-focus regions from each input image by choosing the greatest value for each pixel, resulting in highly focused output. The value of the pixel P (i, j) of each image is taken and compared to each other. The greatest pixel value is assigned to the corresponding pixel [11].

a.iii Principal Component Analysis Algorithm

Principal component analysis (PCA) [12] [10] is a vector space transform often used to reduce multidimensional data sets to lower dimensions for analysis. It reveals the internal structure of data in an unbiased way. We provide below the stepwise description of how we used the PCA algorithm for fusion.

1. Generate the column vectors, respectively, from the input image matrices.
2. Calculate the covariance matrix of the two column vectors formed in 1
3. The diagonal elements of the 2x2 covariance vector would contain the variance of each column vector with itself, respectively.
4. Calculate the Eigen values and the Eigen vectors of the covariance matrix
5. Normalize the column vector corresponding to the larger Eigen

value by dividing each element with mean of the Eigen vector.

6. The values of the normalized Eigen vector act as the weight values which are respectively multiplied with each pixel of the input images.

7. Sum of the two scaled matrices calculated in 6 will be the fused image matrix.

a. iv Liner Discriminate Analysis (LDA)-

LDA is a statistical approach for classifying samples of unknown classes based on the training samples with known classes. This technique aims to maximize between class variance and minimize within class. There is a large variance of data between the classes but little variances within the classes.

It is One of the well-known dimension reduction algorithms that computes a linear transformation Φ by maximizing the following criterion function (Fisher criterion)[14].

$$\phi = \arg\max \frac{\det(\phi^T S_b \phi)}{\det(\phi^T S_w \phi)} \qquad (2)$$

b. Pyramid Fusion Algorithm

The decade of 1980's saw the introduction of pyramid transform [7] [12] - a fusion method in the transform domain. An image pyramid consists of a set of low pass or band pass copies of an image, each copy representing pattern information of a different scale. At every level of fusion using pyramid transform, the pyramid would be half the size of the pyramid in the preceding level and the higher levels will concentrate upon the lower spatial frequencies. The basic idea is to construct the pyramid transform of the fused image from the pyramid transforms of the source images and then the fused image is obtained by taking inverse pyramid transform.

- Typically, every pyramid transform consists of three major phases:
- Decomposition
- Formation of the initial image for recomposition.
- Recomposition

Decomposition is the process where a pyramid is generated successively at each level of the fusion. The depth of fusion or number of levels of fusion is pre decided. Decomposition phase basically consists of the following steps. These steps are performed l number of times, l being the number of levels to which the fusion will be performed.

Low Pass filtering. The different pyramidal methods have a pre defined filter with which are the input images convolved/ filtered with.

Formation of the pyramid for the level from the filtered/convolved input images using Burt's method or Lis Method.

The input images are decimated to half their size, which would act as the input image matrices for the next level of decomposition. Merging the input images is performed after the decomposition process. This resultant image matrix would act as the initial input to the recomposition process. The finally decimated input pair of images is worked upon either by averaging the two decimated input images, selecting the first decimated input image or selecting the second decimated input image. The recomposition is the process wherein, the resultant image is finally developed from the pyramids formed at each level of decomposition.

3. PROPOSED ALGORITHM SELECTION METHOD

The goal of the image fusion is to generate the composite image, which is more informative than its input images. We propose image fusion model by combining LDA and PCA fusion techniques.

The performance of the proposed

method is evaluated in the context of a face recognition application to mitigate the effect of covariate factors such as pose, expression, illumination, and entropy. Match scores computed from two face recognition algorithms, namely **principal component analysis (PCA) [12][10], liner discriminate analysis (LDA), and improve liner discriminate analysis (ILDA),** are fused and the verification performance is compared with existing match score fusion algorithms. Experiments indicate that the proposed fusion architecture efficiently improves the verification performance without increasing the computational cost.

Input to the dynamic selection algorithm is a quality vector which is a quantitative representation of biometric information pertaining to the gallery-probe pair. In the context of face recognition, the quality vector consists of quality score, visual activity level, and pose of the face image. The quality vector $[Q, A, \theta]$ is computed using the following approach.

a. Performance Measures:

The general requirements of an image fusing process are that it should preserve all valid and useful pattern information from the source images, while at the same time it should not introduce artifacts that could interfere with subsequent analyses. The performance measures used in this paper provide some quantitative comparison among different fusion schemes, mainly aiming at measuring the definition of an image.

a.i Entropy (EN) :-

Entropy is an index to evaluate the information quantity contained in an image. If the value of entropy becomes higher after fusing, it indicates that the information increases and the fusion performances are improved. Entropy is defined as:-

$$E = -\sum_{i=0}^{L-1} p_i \log_2 p_i \qquad (4)$$

Where L is the total of grey levels, $p=\{p0,1,\ldots.pL-1\}$ is the probability distribution of each level [1].

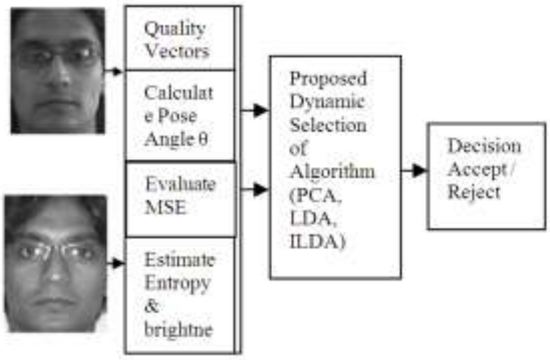

Figure. 1. Block diagram of Algorithms Selection Method

a.ii Mean Squared Error (MSE)

The mathematical equation of MSE is giver by the following equation –

$$MSE = \frac{1}{mn}\sum_{i=1}^{m}\sum_{j=1}^{n}(A_{ij} - B_{ij})^2 \qquad (5)$$

a.iii Pose :-

In face recognition, pose variations can reduce the amount of overlapping biometric features required for recognition. Therefore, it is important to include the head position or angle as a pose parameter in the quality vector. In this research, a fast single view algorithm [5] is used for estimating the pose of a face image. The output of the algorithm is the pose angle which serves as the third element in the quality vector.

a.iv Visual Activity :-

Image properties such as brightness and contrast can be encoded using the visual activity level which is computed using (6),. Activity level is then normalized in the range and used as the second element in the quality vector. A higher activity level represents properly illuminated and contrast normalized image.

$$A=\sqrt{\frac{1}{n^2}[\sum_{i=0}^{n-1}\sum_{j=1}^{n-1}\{(I(i,j)-I(i,j-1)\}^2+\sum_{j=0}^{n-1}\sum_{i=1}^{n-1}\{(I(i,j)-I(i-1,j)\}^2} \quad (6)$$

B. Face Databases Used for Evaluation

To evaluate the performance on a large database with challenging gintra class variations, we combined images from multiple face databases to create a heterogeneous database. The Labeled Faces in the Wild database [12] contains real-world images of celebrities and popular individuals. This database contains images of more than 1600 subjects from which we selected 294 subjects that have at least 6 images

4. PERFORMANCE EVALUATION

The training data is first used to train the proposed fusion algorithm and dynamic selection algorithm

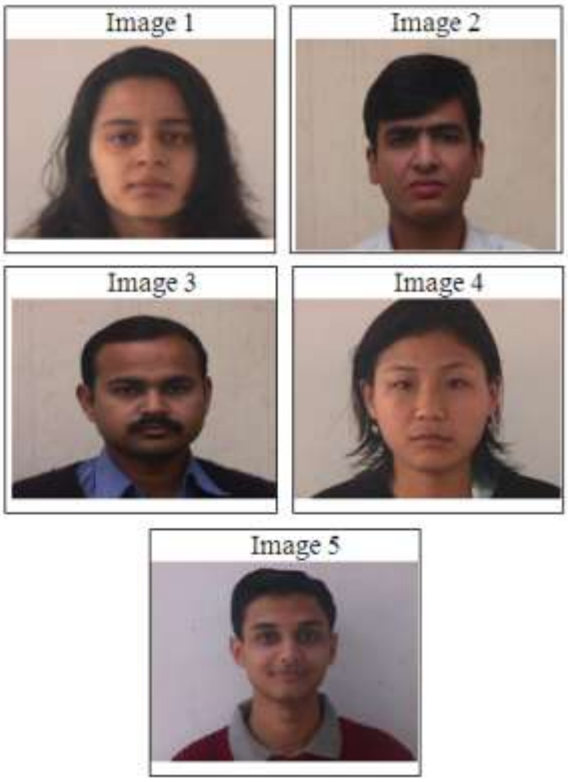

Figure 2. Illustrating examples of input images from the Indian Face Database.

Table 1 : Computation results on different input images

Name of Image	Pose Angle	Entropy	Bright-ness	Selected Algo-rithm
Image 1	-34	7.22	0.31	LDA
Image 2	43	6.9	0.44	PCA
Image 3	8	7.02	0.43	LDA
Image 4	-28	7.2	0.53	LDA
Image 5	-85	6.2	0.58	ILDA

Table 1 Shows the different quality vectors of input images and selected algorithm.

5. CONCLUSIONS

An operational procedure for selection of different fusion methods (PCA, LDA and ILDA) based on quality measures for multimodal biometrics has been presented and evaluated on publicly available Indian face database. This approach is general and optimize both verification accuracy and computation time. Depending on the quality of the input biometric data, the proposed algorithm dynamically selects between various classifiers and fusion rules to recognize an individual. Experimental results on a heterogeneous face database of 250 subjects suggest that the proposed algorithms can significantly improve the verification performance of a face recognition system with low computational overhead.

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