ISSN No. 2278 -3091
Volume 1, No.2, May – June 2012
International Journal of Advanced Trends in Computer Science and Engineering
Available Online at www.warse.org/ijatcse/info.html

Multimodal Biometric system using Gabor Filter

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ABSTRACT

Now days the biometric authentication system is more popular and necessary system for human identification for giving secure access to different systems. In this paper we propose the multimodal biometric system using two traits i.e. face and fingerprint. The final decision is made by feature level fusion. Feature extraction is based on Gabor filter for fingerprint as well face. In the proposed system the stored feature dataset is updated every time hence the proposed system is more reliable than the others. As well as with an accurate authentication system keep the record of login and logout time with total time spend by the user. This system is tested with the standard datasets of face and FVC2004 datasets of fingerprint. The proposed system has lower computational complexity and higher accuracy.

Keywords: Gabor Filter, Face Recognition, Fingerprint Recognition, Fusion, Multimodal Biometrics

1. INTRODUCTION

Biometrics refers to the automatic recognition of individuals based on their physiological and/or behavioral characteristics. Biometric technologies are becoming the foundation of an extensive array of highly secure identification and personal verification solutions. This technology acts as a front end to a system that requires precise identification before it can be accessed or used. Utilizing biometrics for personal authentication is becoming more accurate than current methods (such as the utilization of passwords or Personal Identification Number - PINs) and more convenient (nothing to carry or remember). Thus, Biometrics is not just about security, it's also about convenience. Some of the limitations imposed by unimodal biometric systems can be overcome by including multiple sources of information for establishing identity. In this paper, we show that fingerprint and face recognition can form a good combination for a multimodal biometric system.

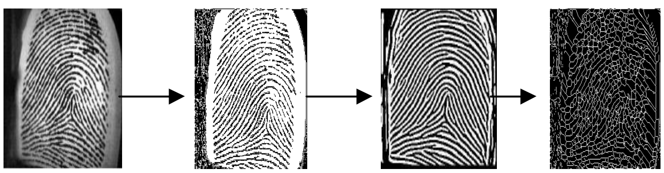
Many researchers have been worked on multimodal system using face and fingerprint. A multimodal biometric system based on feature level fusion of face and fingerprint biometrics in [3] gives the advantages of fusion compared with matching score level. [11] presents an excellent recognition performance over unimodal system using Gabor Wavelet Network(GWN's)for face and LBP for fingerprint.[2]gives the brief overview of the field of biometrics ,also gives its advantages ,strengths, limitations. The proposed system in this paper used two traits face and fingerprint biometrics and the features are extracted by using Gabor filter. [14] presents the individual scores of four traits combined at classifier level and improve the performance of the multimodal system. [15] Shows the performance of some multimodal systems. Our goal is to perform authentication using multiple traits which yield better results than unimodal systems. The output obtained by using Gabor filter is good as compared to the other methods. Gabor filter have the properties of spatial localization, orientation selectivity and spatial-frequency selectivity .Therefore, Gabor filter have been applied to many fields, such as texture classification, face recognition, handwritten character recognition, fingerprint classification and fingerprint recognition. It handles sensitively the different orientations in the fingerprint image and it provide a robust representation is with respect to minor local changes thus, individuals can be recognized in spite of different facial expressions and poses.

The paper is organized as follows: in section 2, we describe the steps of Image preprocessing and face detection .In section 3; we describe the procedure of feature extraction of fingerprint and face. In section 4, feature level fusion is proposed. Then, in section 5 we show the experimental results. In section 6 we draw the conclusion.

2. FINGERPRINT PREPROCESSING AND FACE DETECTION

2.1. Fingerprint Preprocessing

Fingerprint preprocessing is necessary task before proceeding to next step for better identification result. Such process increasing the clarity of ridge structure so that minutiae points can be easily and correctly extracted. The enhanced fingerprint image is binariged and thinned image which has the ridge thickness to one pixel wide for precise location. Preprocessing presents in [5] [13] removes the sensor noise due to fingerprint pressure differences. Figure 1 shows the preprocessing steps. After acquisition of fingerprint from optical scanner the image is stored. The adaptive thresholding is performed by segmenting the image.



Original image Threshold image Binary image Thinned image

Figure 1.Steps followed in fingerprint preprocessing

The binarized image is then submitted to the thinning algorithm to reduce the ridge thickness to one pixel wide to get precise location of minutia points of fingerprint. The processed image is then used to extract the features to form the template.

2.2. Feature Extraction

A fingerprint possesses unique texture structure, which can be described with the orientation field of fingerprints. A fingerprint has the different orientation angle structure in different local area of the fingerprint and has a texture pattern correlation among the neighboring local areas of the fingerprint, bandwidth filter, such as the Gabor filter, can be used to emphasize ridges. The steps followed in feature extraction are; 1) core point detection2) cropping3) calculate the feature vectors using Gabor filter.

Core point Detection

In the proposed system we first detect the core point. The core point is the special point which has the most variant changes in the directions of the lines, i.e.high curvature point of ridges. To differentiate the fingerprint singular points are used. Singular points are the points that can be consistently detected in a fingerprint image and can be used as a registration point. Typically there are two types of singular points: core point and delta point. A fingerprint can have two structures, the global and the local structure. In the global structure the overall pattern of the ridges and valleys are considered where as in local structure the detailed pattern around a minutiae point is considered. A minutiae point is a position in the fingerprint where a ridge is suddenly broken or two ridges are merged. The global structure is used because it is more stable even when the fingerprint is of poor quality [4]. Core points have special symmetry properties which make them easy to identify also by humans. To detect the core point different techniques are used. In our paper core Point detection can be done by using complex filtering [7]. The algorithm proposed for core point detection is:

1. Complex filter of order m are modeled by exp $\{im\Phi\}$. A polynomial approximation of these filters in Gaussian windows yield $(x+iy)g(x,y)$ where g is a Gaussian defined as $g(x,y)=\exp\{-x^2+y^2/2\sigma^2\}$
2. Now these filters are applied not directly to the original enhanced fingerprint image but they are applied to the complex valued orientation tensor field image $z(x,y)=(f_x+if_y)^2$ where f_x is the derivative of the original image in the x-direction and f_y is the derivative in the y-direction.
3. Filters of first order symmetry are used I.e. for core Point:

$$h_1(x,y)=(x+iy)g(x,y)$$
$$=r\exp(i\Phi)g(x,y) \quad (1)$$

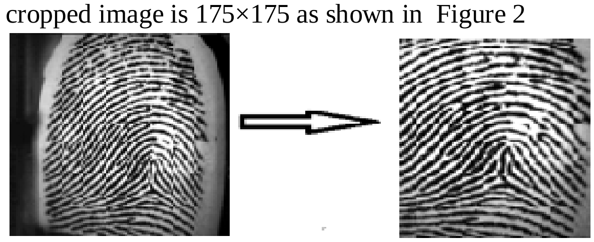
For delta point:

$$h_1(x,y)=(x-iy)g(x,y)$$
$$=r\exp(-i\Phi)g(x,y) \quad (2)$$

Then gradient values are calculated and find the non-zero values. Find the density of the ridges of fingerprint. Then move the 8×8 window and fix the threshold value to 20.Thevalues got from core window get convolved .From the extracted image block the median and variance values are calculated. Then find the maximum variance position that is the core point of the fingerprint image.

Cropping of Image

After locating core point of finger image cropping is done to get only interested area of image and remove unwanted part of the finger for better feature extraction. In our paper the size of cropped image is 175×175 as shown in Figure 2



Original image Cropped image

Figure 2: Image cropping

Feature vector Calculation

After cropping we applied the Gabor filter with sector normalization. A circular region around the core point is located and tessellated into 64 sectors with k=10 and variance=32[1][6]. The pixel intensities in each sector are normalized to a constant mean and variance. In the sector normalization we calculated the average mean value of feature vectors then applied the Gabor filter. Gabor filter is a well known technique to capture useful information in specific band pass channels. The average absolute deviation with in a sector quantifies the underlying ridge structure and is used as a feature. There are 1280 values in length of the feature vector, which is the collection of all the features, computed from all the 64 sectors, in every filtered image. The feature vector captures the local information and the ordered enumeration of the tessellation captures the invariant global relationships among the local patterns presented in [10].

$x=\cos(angle*pi/num\_disk);$

$y=\sin(angle*pi/num\_disk);$

$w=(2*pi)/k;$

$$xx(p)=sinp(i)+cosp(j); \quad (1)$$

$$yy(p)=cosp(i)-sinp(j); \quad (2)$$

$$gaborp(p)=1\times\exp(-((xx(p)\times xx(p))+(yy(p)\times yy(p)))/\ variance) \times \cos(w*xx(p));$$

$$gaborp\_2d(i,j)=gaborp(p); \quad (3)$$

Equation (3) is used to calculate the Gaussian parameters; the output gives the Gabor values. It is desirable to obtain representations for fingerprints which are translation and rotation invariant. In the proposed scheme, translation is taken care of by a reference point which is core point during the feature extraction stage and the image rotation is handled by a cyclic rotation of the feature values in the feature vector. The features are cyclically rotated to generate feature vectors corresponding to different orientations to perform the matching. Hence, the finger can examined at different orientations and this correspond to θ values. These Gabor features are stored in database as template.

At the matching stage the Gabor features of train and test image are compared and distance has been calculated, if the distance is within threshold limit the image is said to be similar.

3. FACE DETECTION AND FEATURE EXTRACTION

Face detection from cluttered images is very tough, due to the change in environment, light effects, facial expressions and different poses of the face. The most popular approaches to face recognition are based on i)the location and shape of facial attributes such as eyes, eyebrows, nose, lips and chin and there spatial relationships ,ii)the overall analysis of face image represents a face as a weighted combinations of number of conical faces. In our proposed system we simply used the Gabor filter with Haar Transformation technique for feature extraction from face which is used for face recognition.

Similarly, like fingerprint before extracting the features from face we followed some preprocessing steps which includes apply Haar transformation algorithm [17] for detecting the face, cropping of image, centralization. Face detection is defined as To determine whether or not there are any faces in the image and if present, return the image location and extent of each face. The challenges of face detection are pose,frontal,45^0,profile,upside down presence or absence of structural components like beards ,mustache, glasses, scarf, facial expressions, occlusion, Image orientation, image condition i.e. lighting ,camera characteristics. The Haar like feature is specified by it's shape, position and the scale. In proposed system we use the Haar like feature algorithm for face detection from open CV library and detect the face. Then face image is cropped after centralizing of the size 175 ×175.As presented in [9][16]feature extraction from face using Gabor filter, the Gabor filter is applied with sector normalization to extract the feature vectors from the image and store that image in training dataset. Figure.3 shows the steps followed in face detection.

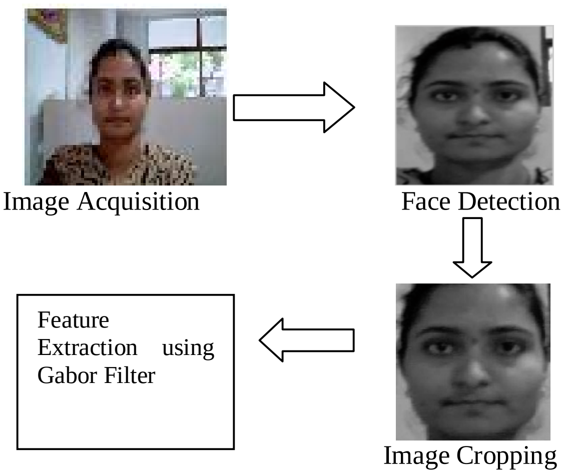


Figure 3: .Steps followed Face feature Extraction

4. PROPOSED MULTIMODAL SYSTEM

4.1. Framework of proposed system

To overcome the problems in the unimodal biometric system .Multi-biometrics are use. With the lower hardware cost a multi biometric system uses multiple sensors for data acquisition. In unimodal system if biometric trait being sensed is noisy then matching result may be not reliable. Hence by using multiple sensors more biometric traits can captured and can get more reliable result. The block diagram of our proposed system is shown in Figure 4. Figure 5 shows the flowchart of our proposed Multimodal system.

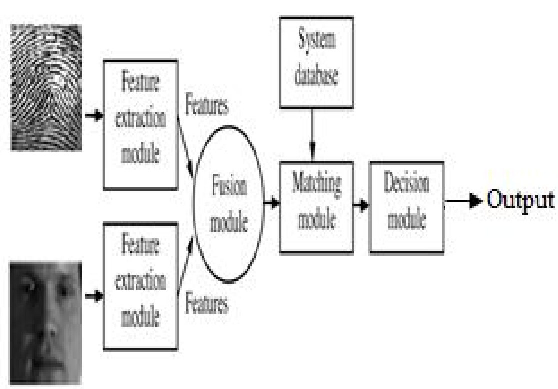


Figure 4: Block diagram of multimodal system

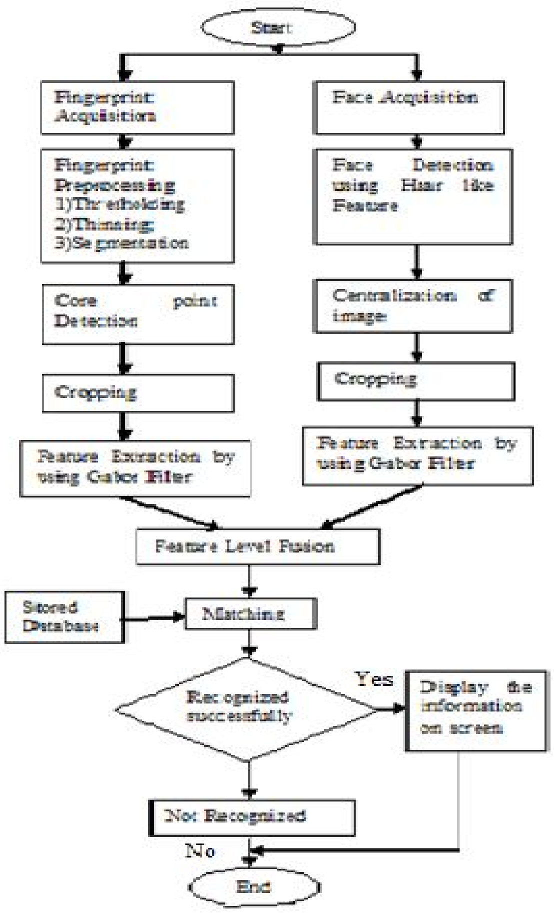


Figure 5: Flowchart of Multimodal system

4.2. Mode of operation

A multimodal biometric system can operate in one of three different modes: serial mode, parallel mode, or hierarchical mode[2]. In our system we used serial mode of operation. In the serial mode of operation, the output of one biometric trait is typically used to narrow down the number of possible identities before the next trait is used. This serves as an indexing scheme in an identification system. In the serial operational mode, the various biometric characteristics do not have to be acquired simultaneously. Further, a decision could be arrived at without acquiring all the traits. This reduces the overall recognition time.

4.3. Fusion

Multimodal biometric systems integrate information presented by multiple biometric indicators[2]. The information can be consolidated at various levels.

a) feature extraction level
b) matching level
c) decision level

We used fusion at feature extraction level because it is considered as a combination scheme applied as early as possible in the recognition system is more effective. i.e an integration at the feature level typically results in a better improvement than at the matching score level.

The proposed system is basically divided into two parts (i)crating profile (ii)identification. In first part the the images are acquired from sensors, features are extracted using Gabor filter , extracted features are get fused then a single feature is saved as template in dataset. In the second part the fingerprint images is taken as query images again the features are extracted and single fused template is compared to the templates stored in dataset for identification. The data set is get updated every time i.e. the stored template is replaced by new extracted template at the time of next authentication .

5. EXPERIMENTAL RESULTS

The reliability of the proposed multimodal system is described with the help of experimental results. The system has been tested on three standard datasets for face and fingerprint(att,ifd,yale,FVC2004DB3).Also the system is tested on the images of fingerprints acquired using optical sensors at a resolution of 500dpi and the face image is acquired using 3-CCD camera. We implemented this method in MATLAB7.5.0(R2007b version) and processed on Pentium machine 20.2 GHz.

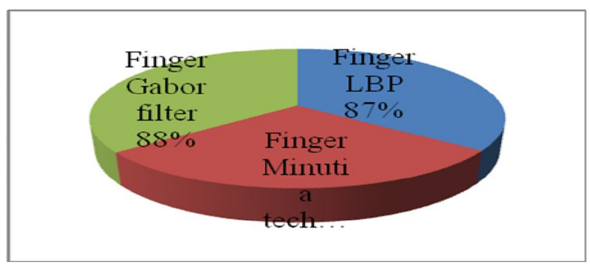


Figure 6: Accuracy of fingerprint unimodal system

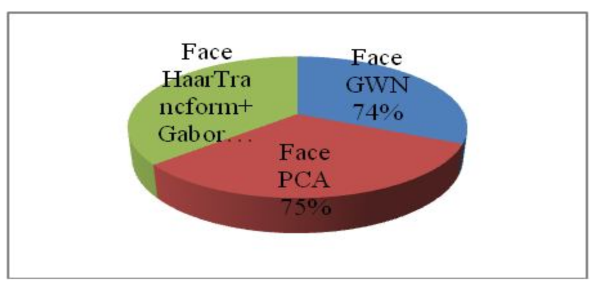


Figure 7: Accuracy of face unimodal system

At first part the individual system were developed and tested for FAR,FRR and Accuracy as shown in Figure 6 and Figure 7 respectively. Table 1 shows the performance of multimodal system in terms of Accuracy, FAR and FRR.

Table 1 : Accuracy, FRR, FAR of multimodal system

Trait	Algorithm	FAR %	FRR %	Accuracy %
Finger	Gabor Filter	0.1	0.17	88
Face	Harr Trancform + Gabor Filter	0.4	0.23	72
Fusion	Gabor Filter	0.11	0.03	97

The performance of the any biometric system is represented by the ROC[8][14](Receiver operating characteristic)curve shown in Figure 8. The ROC curve plots the probability of False Acceptance rate(FAR)versus probability of False Rejection Rate(FRR) for different values of the decision threshold. To show effectiveness of proposed method, we have plotted ROC curve for Genuine Acceptance Rate(GAR)versus FRR.

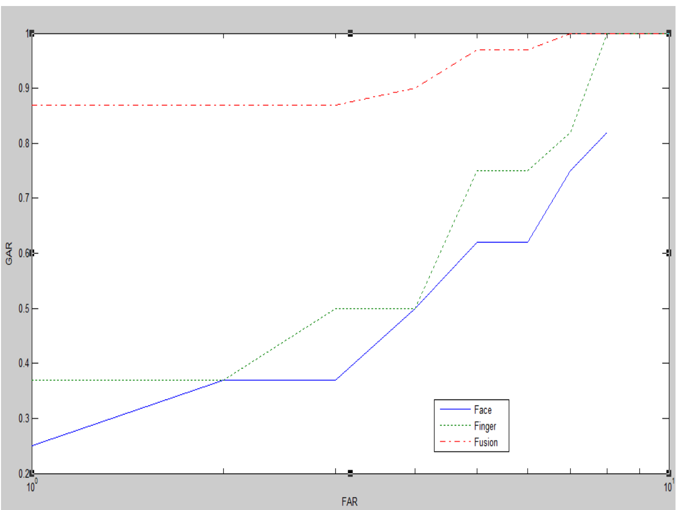


Figure 8 : Roc curve shows the performance of the system

The average CPU time for one test is 1.68sec for face,1.72 sec for fingerprint and 4.21sec for fusion.

6. CONCLUSION

To overcome the problems of traditional unimodal authentication systems we presented an effective biometric multimodal system which utilizes Gabor filter for both fingerprint and face recognition with increased efficiency and accuracy of the person authentication. Fusion is done at feature extraction level which typically results in a better improvement than at the matching score level. The performance table and accuracy curve shows that multimodal system performs better as compared to unimodal system with 97% accuracy poor quality images . In future our next step will be to improve the response time of the system.

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