Multi Feature Fusion Recognition Using Multiple Parallel Support Vector Machine

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Abstract

This paper presents a robust multimodal multifeature biometric authentication scheme integrating iris and lip images based on feature fusion. This paper is one of its kinds, as there is no significant work presented till now that involves multimodal and multifeature. Also, the integration of lip and iris for multimodal is unique. The ROI (region of interest) extraction from the input iris image is obtained using Hough circles. As there are no databases available for lip, the viola face detection algorithm is adopted to obtain the required ROI from the face image. Feature extraction involves the process of extracting multiple features such as texture and line. Hough transform is used for the procurement of the line feature extraction. Canny edge detection algorithm is implemented to obtain Hough transform. Texture feature extraction process is carried out using Haralick method. To surmount the restriction of the possible missing modalities, the multiple parallel support vector machines (SVMs) classification strategy is applied. Fusion of two modalities is carried out at the feature level. This work is to study investigation of better alternative verification techniques suitable for fusion of two modalities, as well as fusion of iris and lip feature at an earlier stage.

Keywords *– Haralick, Iris recognition, Multi feature, SVM, Hough transform.*

1. Introduction

Biometrics is the most modern and effective method of human authentication. It is made possible by identifying and differentiating the traits and characteristics that are unique pertaining to an individual. These different attributes are obtained from various human parts such as iris, fingerprints, palm prints, and other behavioral characteristics that are distinctive to an individual. Biometrics has been the most important tool in law enforcement, access control, forensics, and large-scale identification systems. In recent years there has been a vast improvement in the deployment of biometric systems for official and commercial purposes across the globe. This increase in usage has led to the need of a robust biometric system with an effective false accept rate. Most of the biometric systems currently in use are unimodal. This induces unsatisfactory results when the single modality undergoes a change or is subjected to some transformation. A multimodal biometric authentication fuses the attributes belonging to two different modalities and attains a higher efficiency compared to unimodal biometric systems. So a multimodal fusion of two modalities would be much more effective than the existing unimodal iris systems. So far there is no paper that specifically focuses on multimodal biometric of iris and lip.

1.1 Related Works

Identifying the line and texture features of the lip with high precision is a crucial task. This has been extensively discussed in former works. In [1], a powerful face detection algorithm was used to obtain the region of interest. Next, five various mouth corners were detected and hence the aspect ratio and curvature were formulated. In [2], SIFT and SURF techniques were employed for the extraction and matching of local features of lips. In [3], circular symmetric filters are used to obtain the local characteristics of iris. Further the matching is done using an approach called NFL. A Local Binary Pattern (LBP) algorithm and histogram approaches were used for feature extractions in [4]. The author implemented Linear Vector Quantization (LVQ) Classifier for classification. In [5], different enhancement algorithms are applied on the iris image for preprocessing followed by Haralick method for texture feature extraction and an intelligent classifier technique MSVM is used for classification.

2. Proposed Work

All previous works of iris recognition mostly engage in different kinds of feature extractions employed using a variety of algorithms and thus analyzing the different possible outcomes and their efficiencies. This proposed system indulges in a multimodal system comprising of iris and lip features which can tremendously elevate the performance of the authentication system. The major concerns attached to unimodal authentication like the

IJCSI International Journal of Computer Science Issues, Vol. 11, Issue 2, No 2, March 2014
ISSN (Print): 1694-0814 | ISSN (Online): 1694-0784
www.IJCSI.org

absence of universality are also eliminated with multimodal systems.

The first stage is the acquisition of the region of interest from the input image taken. A Face detection algorithm called Viola face detection algorithm is executed to obtain the lip image from a face image. Hough circle method is incorporated to acquire the iris image. This is followed by an arrangement of filters that process the image to remove noise and sharpen them in order to make the extraction of features easier. Canny edge detection algorithm obtains the edge points in an image thus giving a clear view of the boundary present in an image. Hough transform obtains the line features of both iris and lip. Similarly, Haralick method obtains the texture feature from both the modalities. Now we fuse the texture features of both the modalities together followed by the fusion of line features of both the modalities. The various obtained features are matched to the database and classified using MSVM classification technique. Hyper planes are considered in a large dimensional space and a large number of classes are formed by the interaction of all the planes. Similar patterns and parameters are grouped into the same class and a corresponding decision is made from among the class.

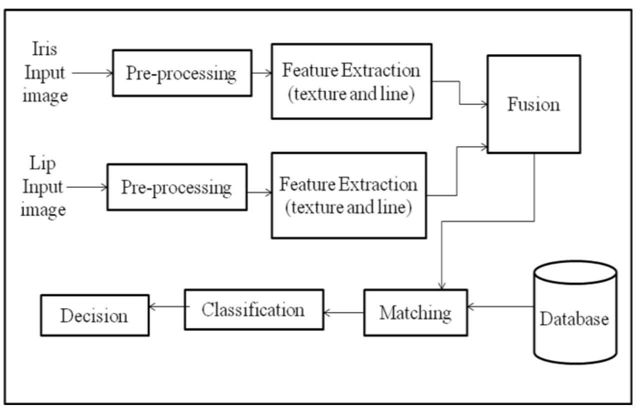

Fig 1: Block Diagram of the Multimodal Biometric Authentication

2.1 Pre - Processing

Image pre-processing enables a significant increase in the reliability of the evaluation process. Pre-processing includes several filter operations which intensifies the input image and reduces noise to a greater extent. The captured iris and lip image have problems as if low contrast and background noise which makes pre-processing an absolute necessity. This preprocessing system involves a ROI extraction algorithm followed by filters to remove noise and to sharpen the image.

The first stage of pre-processing involves the extraction of region of interest. A very efficient method called viola face detection algorithm is used to extract the lip region from the face of the individual in an image. This algorithm can obtain multiple features from the face.

Fig 2: Face Input image for the extraction of the lip

Fig 3: Extracted lip from the face database using viola Jones detection

In case of iris, Hough circle method is implemented to extract the iris from the eye image.

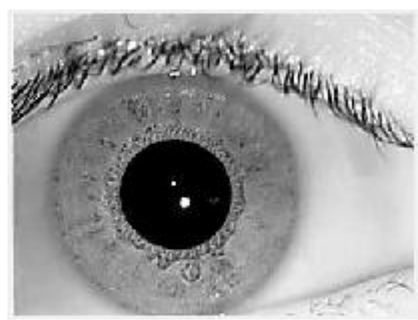

Fig 4: Eye Input image for the extraction of the iris

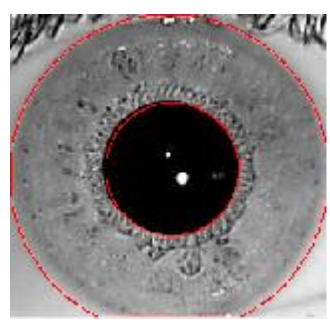

Fig 5: Extracted iris from the eye database using Hough circle

The extraction of the ROI is succeeded by the application of Gaussian filter to remove noise.

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{\frac{-(x^2+y^2)}{2\sigma^2}} \quad (1)$$

The next step in preprocessing is enhancing the image using sharpening filter.

3. Feature Extraction

It is the process of acquiring higher-level information of an image, such as colour, shape, and texture. Features contain the relevant information of an image and will be used in image processing (e.g. searching, retrieval, storing). Features divided into different classes based on the kind of properties they describe. The extraction of features from the pre-processed image is the most vital stage in an authentication system. This particular system has a combination of line and texture feature extraction methods. Line extraction deals with the acquisition of features that deal with the boundary points and edges in an image whereas texture extraction deals with obtaining features of contrast, correlation, entropy.

3.1 Hough Line Extraction

Hough transform is one of the best methods used in image processing for line extraction. It is a method for estimating the parameters of a shape from its boundary points.

$$w = x * \cos(f) + y * \sin(f) \quad (2)$$

where, f is the angle to the horizontal.

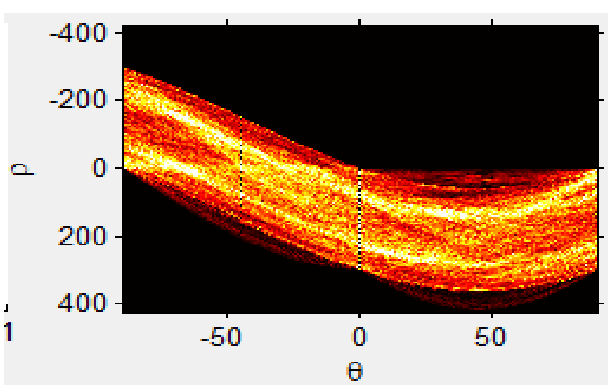

Fig 6: Hough Transform of the iris for line feature extraction

Hough transform can detect lines, circles and other structures if their parametric equation is known. It can give robust detection under noise and partial occlusion.

Hough transform method is preceded by edge detection mechanism to enhance the boundary edges. Canny edge detection algorithm is implemented to obtain Hough transform.

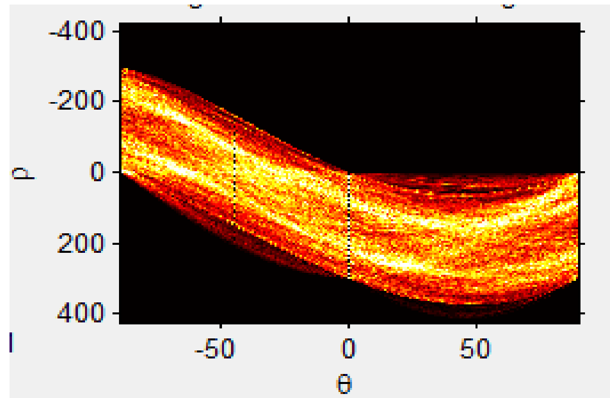

Fig 7: Hough Transform of the lip for line feature extraction

3.2 Haralick Texture Extractions

Texture is a very general notion that is difficult to describe in words. Haralick introduced the co occurrence matrix and his texture features, which are the most popular second order statistical features today. Haralick proposed two steps for texture feature extraction: the first is computing the co-occurrence matrix and the second step is calculating texture feature base on the co-occurrence matrix. This technique is useful in wide range of image analysis applications from biomedical to remote sensing techniques. It considers the relationship between two neighbouring pixels, the pixel known as a reference and the second known as a neighbour pixel is as follows

$$\{I(x,y), 0 \le x \le N_x - 1, o \le y \le N_y - 1\} \quad (3)$$

to denote an image with G gray levels. The G x G gray level co-occurrence matrix P_d^θ for a displacement vector d = (dx; dy) and direction of P_d^θ is defined as follows. The element (i; j) of P_d^θ is the number of occurrences of the pair of gray levels i and j which the distance between I and J following direction θ is d.

$$P_d^\theta(i,j) = \#\{((r,s),(t,v)) : I(r,s) = i, I(t,v) = j\} \quad (4)$$

where (r,s) , (t,v) ∈ $N_x \times N_y$;(t,v)=(r+dx,s+dy).

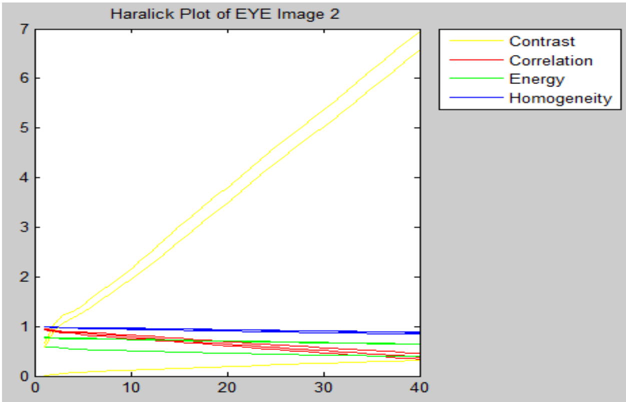

Fig 8: Haralick method of the iris for texture feature extraction

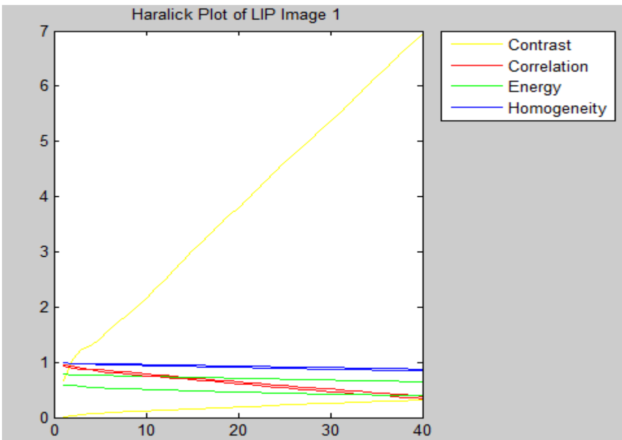

Fig 9: Haralick method of the lip for texture feature extraction

3.3 Contrast Feature

Contrast is a measure of intensity or gray-level variations between the reference pixels and its neighbor. In the visual perception of the real world, contrast determined by the difference in the colour and brightness of the object and other objects within the same field of view.

$$f = \sum_{n=0}^{N_g-1} n^2 \left\{ \sum_{i=0}^{N_g-1} \sum_{j=0}^{N_g-1} p_{d,\theta}(i,j) \right\} \quad (5)$$

$$n = | i - j |$$

When i and j are equal, the cell is on the diagonal and i - j = 0. These values represent pixels entirely similar to their neighbor, so they are given a weight of 0. If i and j differ by 1, there is a small contrast, and the weight is 1. If i and j differ by 2, the contrast is increasing and the weight is 4. The weights continue to increase exponentially as (i - j) increases.

3.4 Entropy Feature

Entropy is a difficult term to define. The concept comes from thermodynamics; it refers to the quantity of energy that is permanently lost to heat every time a reaction or a physical transformation occurs. Entropy cannot be recovered to do useful work. Because of this, the term can be understood as amount of irremediable chaos or disorder. The equation of entropy is:

$$f = \sum_{i=0}^{N_g-1} \sum_{j=0}^{N_g-1} p_{d,\theta}(i,j) \log(p_{d,\theta}(i,j)) \quad (6)$$

3.5 Correlation Feature

Correlation feature shows the linear dependency of gray level values in the co-occurrence matrix. It presents how a reference pixel is related to its neighbor, zero is uncorrelated, 1 is perfectly correlated.

$$f = \sum_{i=0}^{N_g-1} \sum_{j=0}^{N_g-1} p_{d,\theta}(i,j) \frac{(i-\mu_x)(j-\mu_y)}{\sigma_x \sigma_y} \quad (7)$$

where μ_x, μ_y and σ_x, σ_y are the means and standard deviations of p_x *and* p_y

$$\mu_y = \sum_{i=0}^{N_g-1} \sum_{j=0}^{N_g-1} i.p_{d,\theta}(i,j)$$

$$\mu_y = \sum_{i=0}^{N_g-1} \sum_{j=0}^{N_g-1} j.p_{d,\theta}(i,j)$$

$$\sigma_x = \sqrt{\sum_{i=0}^{N_g-1} \sum_{j=0}^{N_g-1} (i-\mu)^2 p_{d,\theta}(i,j)}$$

$$\sigma_y = \sqrt{\sum_{i=0}^{N_g-1} \sum_{j=0}^{N_g-1} (j-\mu)^2 p_{d,\theta}(i,j)} \quad (8)$$

For the symmetrical GLCM,

$$\mu_x = \mu_y$$

$$\sigma_x = \sigma_y$$

3.6 Inverse Difference Moment (IDM) Feature

IDM usually called as homogeneity that measures the local homogeneity of an image. IDM feature obtains the measures of the closeness of the distribution of the GLCM elements to the GLCM diagonal

$$f = \sum_{i=0}^{N_g-1}\sum_{j=0}^{N_g-1}\frac{1}{1+(i-j)^2}\,p_{d,\theta}(i,j) \tag{9}$$

IDM weight value is the inverse of the Contrast weight, with weights decreasing exponentially away from the diagonal.

4. Multi Feature Fusion

Fusion is the process of combining the extracted features which were obtained from the previous stage. A multimodal and a multi-feature authentication system require fusion as a necessity. Since the system we develop involves multimodal and multifeature systems we employ fusion technique twice. Here, feature level fusion is implemented as it gives the most efficient authentication for this particular system.

5. MSVM Classification

Image classification analyzes the numerical properties of various image features and organizes data into categories. All classification algorithms are based on the assumption that the image in question depicts one or more features and that each of these features belongs to one of several distinct and exclusive classes.

Here, MSVM (multiple parallel support vector machines) is used to achieve classification. Support vector machine consists of a hyper plane that distinguishes separable patterns. MSVM is an extension of support vector machine done in multi-categories. Support vectors are the data points that lie closest to the decision surface. Support Vectors: Input vectors for which

$$W_0^T X + b_0 = 1$$
$$or$$
$$W_0^T X + b_0 = -1$$

$$X_i^o W + b \geq +1$$
$$when$$
$$y_i = +1$$

The hyper plane that divides the features into their corresponding classes is defined as

$$X_i^o W + b \leq +1$$
$$when$$
$$y_i = -1$$

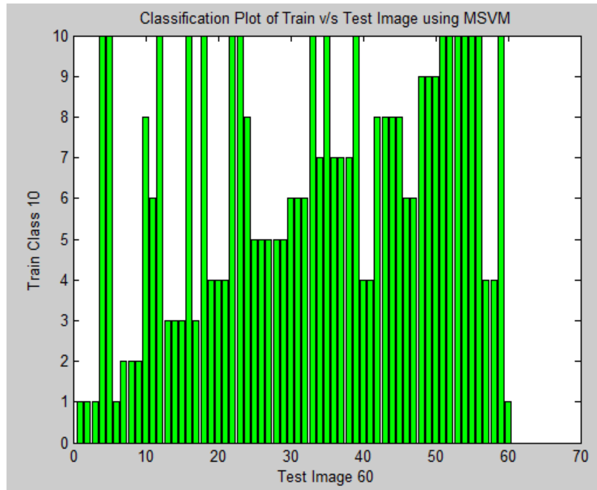

Fig 8 : MSVM classification of the fused feature for train image Vs test images

6. Experiment Result

We test the proposed feature extraction and classification methods on the Chinese Academy of Sciences' Institute of Automation (CASIA) iris and face database to prove the effectiveness of the approach.

Database

The CASIA database consists of 4000 images of face captured from 1000 subjects and 2500 images of iris captured from 428 subjects. Images from this database undergo ROI extraction. The ROI extracted images are then processed to extract multiple features (texture and line) of iris and lip. The images are then classified within the database. Matching is done to check for the accuracy of the proposed method. This is done by comparing each image with the database images.

This section puts forward the experiments conducted to evaluate the performance of the feature-extracted images of lip and iris using Hough transform and Haralick method. Extraction is followed by feature level fusion and matching of the fusion with the database, which is done using Euclidean distance matching formula and further classified by implementing the MSVM technique. Here, 6 images for each subject are considered, three are used for training, and the remaining three are used for testing purpose. The performance of this authentication system is evaluated.

The final step deals with performing verification experiments for testing the method proposed in this paper. In order to identify the test image, classification of all the images in the database is necessary. Templates are generated for each class. The sample images are compared with all the template classes and the results are produced. By seeing the results, we get to know that the proposed method leads to absolute accuracy of 92%.

7. Conclusion

This paper presented a novel approach for multimodal multifeature biometric authentication using feature fusion. The modalities taken into account are iris and lip. The multifeature involves texture and line. We propose Haralick method for texture feature extraction, line extraction using Hough transform and a multiple parallel support vector machine (MSVM) technique for classification which overcomes the shortcomings of algorithms presented earlier. The proposed MSVM based Multifeature recognition method obtained an performance accuracy of 92%.

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