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A NOVEL MULTIMODAL BIOMETRIC SCHEME FOR PERSONAL AUTHENTICATION

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ABSTRACT

Biometrics has long being touted as a powerful tool for solving identification and authentication issues for immigration and customs, forensics, physical and computer security. In real world situations, unimodal biometric systems repeatedly face significant restrictions due to noise in sensed data, spoof attacks, lack of distinctiveness, data quality, restricted degree of freedom, non-universality, and other factors. Multimodal biometric systems are used to increase the performance as well as better security that may not be achievable by using unimodal biometrics. Gabor filter, Gabor filter bank, Gabor transform and Gabor wavelet are widely applied to image processing, computer vision and pattern recognition. This Gabor function can provide accurate time-frequency location. In this paper we proposed a theoretical Novel approach for multimodal biometric system for personal authentication in which features are extracted from different biometric traits like – palm print, iris, and finger print. The features extracted using Gabor filters from multiple biometrics are combined at feature level and to perform authentication, a classifier SVM is used to classify the claimed identity as genuine or imposter.

KEYWORDS: Feature Level Fusion, Gabor Filter, Multibiometrics, Support Vector Machines

INTRODUCTION

Biometrics is the science of determining the identity of a person based on the physiological / behavioural characteristics of the individual. A person can be identified by using biometrics based on ‘what you are’ rather than ‘what you possess’ such as ID card or ‘what you remember’ such as password [1]. Biometrics are incorporated in many different applications because of the need for reliable user authentication techniques has increased in the wake of heightened concerns about security, and rapid advances in communication, networking and mobility [45]. A variety of biometric characteristics including face, fingerprint, palm print, iris, retina, signature, gait, ear, hand vein, voice pattern, odor or DNA are being used in various applications. Each biometric has its merits and demerits. Therefore, the selection of a biometric trait depends on several issues other than matching performance. [45] have identified some factors that determine the suitability of biometric trait.

Now a day in a real world, fingerprint, face, iris, palm print, and retina have been highly explored. Hand – based biometric has many advantages over other biometrics, including small feature size, low cost of computation as a result of using low resolution images, and it has higher user acceptance and is more user friendly [palm authentication 6, 28]. The most evident structural characteristic of a fingerprint is a pattern of interleaved *ridges* and *valleys*; in a fingerprint image, ridges (also called ridge lines) are dark whereas valleys are bright. Fingerprints will offer a reliable means of personal authentication [6]. However due to their problematic skin or physical work, some people may not have clear fingerprints.

Among the present biometric traits, iris has high accuracy and most reliable due to unique structure, rich texture of iris patterns, persistence of features through life time of an individual [2]. The iris of an eye is the annular part between the black pupil and the white sclera (Figure.1). There are lots of irregular small blobs, such as freckles, coronas, stripes, furrows and crypts, etc., overlaying on the iris region. The spatial distribution of these blocks in the iris is also random. Such randomly distributed and irregular blocks constitute the most distinguishing characteristics of the iris [biometric authentication by david22]. The visual texture of the iris is formed during fetal development and stabilizes during the first two years of life [1]. Each iris is unique and even identical twins have different.

In recent times, palm print has acknowledged more concentration. A palm print contains rich distinct information like ridges, wrinkles, principle lines. When compared to other biometrics palm print has several advantages: (i) higher user acceptance (ii) stable line features (iii) low-resolution imaging (iv) low intrusiveness.

No single biometric is expected to effectively meet all the requirements (e.g. cost, accuracy, practicality) imposed by all applications. The performance of biometric system using single trait is constrained by several factors. For example, if the face modality is used the upper limit on the performance will be based on the number of identical twins. Similarly, if the voice biometric is used, the performance is limited by the number of persons who are unable to speak coherently. This inherent limitation can be alleviated by fusing the information presented by multiple sources. For example, the face and fingerprint traits, or multiple images of the face, or fingerprint and palm print, or the fingerprints of the right and left index fingers of a person may be used together to resolve the identity of an individual. In biometrics a person can be represented in feature space, which can be expanded by fusion. This fusion increases the number of individuals that can be effectively enrolled in a certain personal identification system. A multi biometric system or multimodal biometric system is a system that integrates the evidence presented by multiple biometric sources. Due to the presence of multiple pieces of evidence, these systems are expected to be more reliable (Hong et al., 1999). Multi biometrics alleviates some of the limitations of unibiometric systems by combining the evidence presented by multiple biometric sources. This information fusion can enhance the matching accuracy of a recognition system. Thus, a properly designed multi biometric system have several advantages over unibiometric systems like improvement in matching accuracy, increase population coverage, addresses the issue of non-universality and the problem of noisy data, diminish spoofing activities.

Therefore, in order to increase the performance of the automated system, it is advisable to go for multimodal biometrics. Multimodal biometric techniques have attracted much attention as the additional information between different biometric could get better recognition performance.

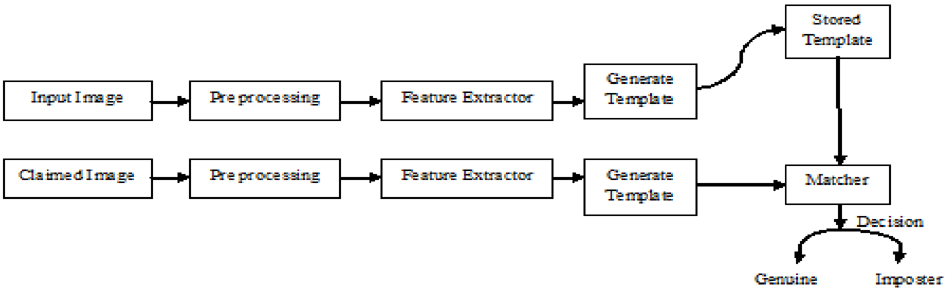

Figure 1: Basic Block Diagram of Biometric System

A Multi biometrics authentication system consists of the following steps: Image capturing, pre-processing, feature extraction, feature fusion and matching. Images are captured by using sensors. At pre-processing step, to remove noise and unwanted area from the image is enhanced. Feature extraction step retrieves the features from the image.

Feature extraction of palm print, iris and fingerprint are different. By using Gabor filter features can be extracted from three modalities. After feature extraction, fusion takes place to combine the different features and stored in database as template. A matching algorithm is used to compare the template of the claimed identity with the stored one in the database.

RELATED WORK

Biometric based recognition is more popular and getting wide acceptance in different areas. In biometric systems, for identification initially image has to be captured. Pre processing is support to be done as initial step. In real world situation, due to the environmental conditions the image may be blurred. With wise in this situation a good pre processing method is required. Fingerprint image can be smoothened by using Low pass filters like Gaussian. In [3] Short Time Fourier Transform (STFT) analysis is adopted in addition to Gaussian filter to increase the quality of the fingerprint image. Sometimes a number of false minutiae may present in binarized finger print image. In [4] detailed pre processing is specified to remove false minutiae.

Iris Pre processing includes localization, normalization and enhancement. To localize the iris image integro differential operator (IDO) is proposed [2]. Hough transform technique is used to localize iris [6]. [6-7] proposed simple filtering and histogram operations for iris segmentation. [8] Locates iris inner boundary by deploying wavelet transform and for outer boundary Daugman's IDO is applied. Before feature extraction, it is essential to obtain an image from the captured palm print image by eliminating the variations caused by rotations and translations or noise due to environmental conditions. The five steps to pre-process the palm print image is discussed in[9].

After pre processing, features are extracted from images. In literature [10] minutiae extraction algorithm is applied to fingerprint images of either good or poor quality. [11] used Gabor filter to extract features from fingerprint. Palm print analysis using Gabor filters [12], wavelets [13], local texture energy [15] and Fourier Transform [14] has been proposed in literature. There are several methods proposed for iris feature extraction in literature. Several works used Gabor filter [2] [5] [16], Zero crossing wavelet transform [17], Laplacian – of- Gaussian filter [18], etc, for iris feature extraction.

In Multi biometric systems, features from different biometrics are combined at any level like sensor level, feature level, matching score level, decision level. Palm print and iris are combined in feature level [19]. Fusion at matching score level is used in [20]. So feature level fusion gives better performance [21]. As different fusion methods are available, the comparison of these methods is presented in [22]. Discrete Wavelet Transform (DWT) and Principal Component Analysis(PCA), Morphological processing and Combination of DWT with PCA and Morphological techniques have been popular fusion of image[23][24][25].

Matching is the process of calculating the degree of similarity between the input test image and training image from database. Matching can be performed in three ways: Hierarchical approach, classification and coding. The classification is combining of the cluster of images between test image and trained image. KNN classifier [19], nearest neighbour classifier (1-NN) [26] is some classifiers used in literature.

A block diagram of basic biometric system shown in Figure1. Bellow steps give a brief summary about different steps in proposed system.

- Input palm print, finger print and iris image as input.
- Select the features from palm print, iris, finger print using Gabor filter.
- The features are combined by Discrete Wavelet Transform (DWT), Principal Component Analysis (PCA) & Independent Component Analysis (ICA).
- Support Vector Machine is used for image classification.

METHODOLOGY

The basic block diagram of the proposed method is shown in Figure 2. Proposed system for multimodal biometric based personal authentication focuses on the feature level fusion. This methodology has the benefit of exploiting more amount of information from each biometric. Figure 2 comprises of pre-processing, feature extraction, fusion and matching. The unwanted data in the input image is removed in Pre processing.

Feature extraction is done using Minutiae extraction for fingerprint and Local Binary Pattern for palm print. Fusion is done using the Discrete Wavelet transform, Principal Component Analysis and Independent Component Analysis. At the enrollment stage these fused images are stored in the database. At the authentication stage, the above steps are again done for Iris, palm print and fingerprint images.

With the templates of the database, these features are then compared to produce the output. By using the SVM matching is done. Combining multiple biometric systems reduces error rates and improves accuracy. The proposed system overcomes the limitations of unimodal systems and also meets the accuracy requirements. The details of the steps in the proposed system are described in the following sections.

Preprocessing

The image is pre-processed to reduce the noise and secular reflections as much as possible to improve the quality of the image. To make single image size, all images must be normalized. This is the first step of pre processing.

Fingerprint Preprocessing: Apply a low-pass filter for fingerprint images. Then a threshold T_p is used to convert the original image into binary image. Mathematically, this transformation is represented as

$$B(x, y) = 1 \text{ if } O(x, y)*L(x, y) \geq T_p, \tag{1}$$

$$B(x, y) = 0 \text{ if } O(x, y)*L(x, y) < T_p, \tag{2}$$

Where B(x, y) and O(x, y) are the binary image and the original image, L(x, y) is a low pass filter, such as Gaussian and * represents an operator of convolution. Then, compute fingerprint skeleton from binary image by using a thinning algorithm [26-27].

Before applying thinning to binary image several techniques are proposed [4] to avoid a number of spurious minutiae in the skeleton images which are introduced due to the misconnections and the isolated regions (hole, dot, and island) in the binary images.

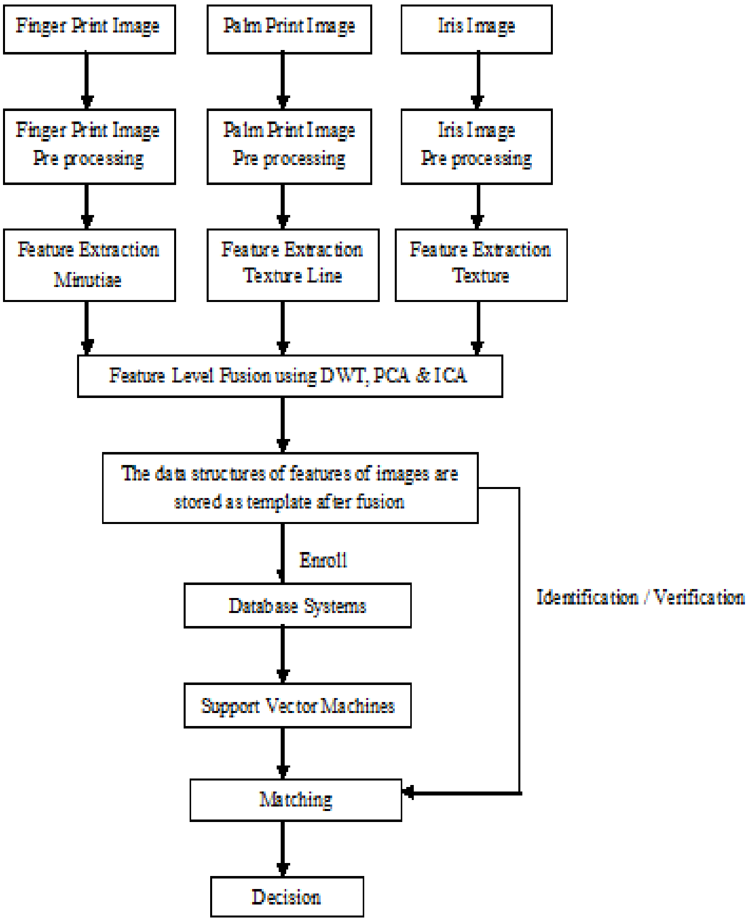

Figure 2: Proposed Multimodal Authentication System

Palmprint Preprocessing: By using the pre processing method [29] for palm print obtain a sub-image from the original image to eliminate the variations caused by rotation and translation. In first step, apply low pass filter to palm print image like fingerprint to get binary image. Then by using boundary tracking algorithm extract the boundaries of holes, ($F_i x_j, F_i y_j$) (i = 1; 2). The start points, (Sx_i, Sy_i), and end points, (Ex_i, Ey_i) of the holes are then marked in the process. In Step 3, Compute the centre of gravity, (Cx_i, Cy_i), of each hole. Then construct a line passes through centre of gravity and the midpoint of start and end points. Based on these lines, two key points, (k_1, k_2) can be detected. In the next step, Line up k_1 and k_2 to get Y-axis of the palm print coordinate system and make a line through their mid point to determine the origin of the coordinate system. This coordinate system can align different palm print images. In last step, extract sub image with fixed size on the basis of coordinate system, which is located at particular part of the palm print for feature extraction.

Iris Preprocessing: Irises of different images from the same eye may be variable due to pupil dilation, camera-to-eye distance, head tilt, and eye rotation within its socket. Therefore, before feature extracting the original image needs to be pre-processed to localize and normalize the iris. In Iris pre processing, reduce the papillary area to pure black, in order to properly recognize the inner papillary boundary and remove bright flashes present in the image. Location of the pupil and outer iris boundaries is the first stage in iris pre processing. By image segmentation iris is detected and extracted from an eye image. Segmentation of iris depends on the quality of the eye images. An automatic segmentation algorithm based on the circular Hough transform [30] is used.

The Hough transform is defined as

$$H(x_c, y_c, r) = \sum_{j=1}^{n} h(x_j, y_j, x_c, y_c, r) \quad (3)$$

Where,

$$h(x_j, y_j, x_c, y_c, r) = \begin{cases} 1, if\ g((x_j, y_j, x_c, y_c, r) \\ 0, otherwise \end{cases} \quad (4)$$

Due to the dilation and constriction of the human pupil, the radial size of the iris varies under different illumination conditions and in response to physiological factors. Such elastic deformation in iris will affect the result of iris matching. In order to compensate this deformation, a normalization process is needed to transform the located iris into fixed dimension. In next step segmented iris is normalized. The normalization process produce an iris region, which have the same constant dimensions, so that two images of the same iris under different conditions will have characteristic features at the same spatial location.

Feature Extraction

Feature extraction is a key process where two dimensional image is converted to a set of mathematical parameters. Gabor filter-based features have been successfully and widely applied to texture segmentation [31], face recognition [32], handwriting recognition [33] and fingerprint enhancement [34]. This is because the characteristics of the Gabor filter, especially the frequency and orientation representations, are similar to those of the human visual system [35].

A circular 2-D Gabor filter in the spatial domain has the following general form

$$G(x, y, \Theta, u, \sigma) = \frac{1}{2\pi\sigma^2}\, exp\left\{-\frac{x^2+y^2}{2\sigma^2}\right\} \times exp\{2\pi i(ux\cos\theta + uy\sin\theta)\}, \quad (4)$$

where $i=\sqrt{-1}$; u is the frequency of the sinusoidal wave; Θ controls the orientation of the function and σ is the standard deviation of the Gaussian envelope. In addition to accurate time-frequency location, they also provide robustness against varying brightness and contrast of images.

By using the method proposed in [11] minutiae are extracted from fingerprint using Gabor filter. The Cosine/sine form and the sinusoidal-shape of Gabor filters is suitable for modelling ridge/valley structures and smoothing out noise, respectively. In fact, a Gabor function, G(x, y, Θ, u, σ) with a special set of parameters (σ, Θ, u), is transformed into a discrete Gabor filter, G[x, y, Θ, u, σ]. In order to provide more robustness to brightness, the Gabor filter is turned to zero DC (direct current) with the application of the following formula:

$$\tilde{G}[x, y, \theta, u, \sigma] = G[x, y, \Theta, u, \sigma] - \frac{\sum_{i=-n}^{n}\sum_{j=-n}^{n} G[i,j,\theta,\sigma]}{(2n+1)^2} \quad (5)$$

where $(2n+1)^2$ is the size of the filter. In fact, the imaginary part of the Gabor filter automatically has zero DC because of odd symmetry. This adjusted Gabor filter will convolute with a sub-image defined in pre processing. The sample point in the filtered image is coded to two bits, (b_r, b_i), by the following inequalities,

$$b_r = 1 \text{ if } Re[\tilde{G}[x, y, \theta, u, \sigma] * I] \geq 0, \quad (6)$$

$$b_r = 0 \text{ if } Re[\tilde{}\tilde{G}[x, y, \theta, u, \sigma] * I] < 0, \quad (7)$$

$$b_i = 1 \text{ if } Im[\tilde{G}[x, y, \theta, u, \sigma] * I] \geq 0, \quad (8)$$

$b_i = 0$ if $\text{Im}[\tilde{G}\,[x, y, \theta, u, \sigma] * I\,] < 0$, (9)

where I is the sub-image of a palm print. Using this coding method, only the phase information in palm print images is stored in the feature vector. The size of the feature is 256 bytes. This texture feature extraction method has been applied to iris feature extraction [2].

Feature Fusion

The various levels of fusion in biometric systems can done by combination of two or more biometric traits are: (i) pixel level fusion (ii) feature level fusion (iii) matching score level fusion (iv) decision level fusion. In feature level fusion, the feature vectors are extracted from different biometric traits which are combined into new feature vector. The new feature vector contains richer information when compared to information after fusion by applying other fusion techniques. From large set of features, valuable features can be extracted by using feature reduction techniques.

Various methods have been developed for fusion. Some of them are:

- Intensity-hue-saturation (IHS) transform based fusion,
- Principal Component Analysis (PCA) based fusion,
- Multi scale transform based fusion- which is categorized into several methods. They are (a) High-pass filtering method, (b) Pyramid method, which is classified as (i) Gaussian pyramid, (ii) Laplacian Pyramid, (iii) Gradient pyramid, (iv) Morphological pyramid, (v) Ratio of low pass pyramid, (vi) Contrast pyramid., (c) Wavelet transform- different wavelet based fusion techniques are (i) Discrete wavelet transform (DWT), (ii) Stationary wavelet transform, (iii) Dual tree discrete wavelet transform, (iv) Lifting wavelet transform, (v) Multi-wavelet transform, and (d) Curvelet transform.
- Biologically inspired information fusion
- Arithmetic combinations, various fusion methods in this technique are (a) Brovey transform, (b) Synthetic variable ratio technique, (c) Ratio enhancement technique.
- Total probability density fusion

As different fusion methods are available, the comparison of these methods is presented in [35]. Discrete Wavelet Transform (DWT) and Principal Component Analysis(PCA), Morphological processing and Combination of DWT with PCA and Morphological techniques have been popular for fusion of image[36][37][38]. These methods are shown to perform much better. Here to fuse three biometric modalities, a combination of DWT, PCA and ICA is used, which is expected to give better performance.

Support Vector Machines

In Biometrics identification is more computational and time demanding one when compared to the identity verification. Therefore a more specialized classification-based biometric system should be approached in order not only to achieve the desired performance improvement, but also to decrease the execution time. Commonly used classifiers for different biometrics are Gaussian mixture models-based classifiers, neural networks and KNN classifiers. Statistical learning theory has the ability to absorb both the variability and the similarity between patterns. Support Vector Machine

(SVM) is a powerful learning tool based on statistical learning theory and Machine learning. SVM has superior results in various classification and pattern recognition problems [39, 40]. For several pattern classification applications, SVM provides better generalization performance than conventional techniques especially when the number of input variables is large [41, 42]. With this purpose in mind, we evaluated the SVM for our fused feature vector.

The standard SVM takes a set of input data. It is a predictive algorithm to pinpoint the class to which the input belongs. This makes the SVM a non-probabilistic binary linear classifier [43] which makes its decision by constructing a linear decision boundary or hyper plane that optimally separate data points of the two classes in feature hyperspace and also makes the margin maximized. SVMs have many advantages over Neural Networks. ANN are prone to the danger of over training [44] resulting in a solution over-fitted to the database being worked on. This could lead to overly optimistic results and accuracy outcomes. It has been found that SVMs are comparatively faster to train than ANNs.

CONCLUSIONS

Multi biometric systems are more resistive towards spoof attacks and gives good performance when compared to unibiometric counterpart. In this paper, we proposed a theoretical approach for personal authentication which is evaluated using multimodal biometrics – the fusion of fingerprint, palm print and iris at feature level. Biometrics trait like iris is internal part of human and is less prone to damage. They can be employed with other biometric traits like fingerprint, palm print in high security applications. Proposed system extracts Gabor texture from pre processed iris, palm print and fingerprint image. The extracted features are fused using a wavelet based feature fusion technique. Features taken from different biometric traits are in different sizes. Therefore, we propose discrete wavelet-based fusion techniques for feature level fusion in combination with PCA & ICA. The future work will involve evaluation of feature level fusion being developed for different fingerprint, palm print and iris databases in terms of false accept rates, false reject rates.

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