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Minutiae Based Feature Level Fusion for Multimodal Biometrics

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Abstract

Multimodal biometrics aims to authenticate an individual with the help of one or more biometric traits. This paper has focused on integrating the minutiae features of retina and fingerprint with feature level fusion. Time optimization is done using Clustering. Extracted Minutiae features of both fingerprint and retina are clustered using K-means Clustering and they are Indexed. Clustered and Indexed data stored in a database is compared with the query future and nearest neighbourhood clusters are identified. Decision is made based on the similarity measure. The proposed system provides an authentication with GAR = 99.96%, FAR = 0.4%.

Keywords: Multimodal Biometrics, Fingerprint, retina, K-Means clustering, Nearest Neighbour Cluster.

INTRODUCTION

Biometrics is a automated method of identifying a person or verifying the identity of a person based on the persons' body part. Authentication can be performed using biometric system. A biometric system is defined as a system which automatically distinguishes and recognizes a person as individual and unique based on certain physiological or behavioral characteristics that are inherent to that person". Physiological biometric traits involve some form of physical measurement used for biometric recognition, which includes hand geometry, fingerprint, knuckle print, palm print, face, ear, iris, retina and DNA. Behavioral biometric traits is the method of authenticating a person based the way by which a particular person performs a task, it include gait, voice, keystroke and signature. The choice of biometric characteristics depends on the application. Moreover, a Biometric Characteristics must satisfy the following characteristics.

Uniqueness

Something that separate one person form other. Biometric characteristic must have unique properties in order to distinguish one person from other.

Collectability

Characteristics must be measurable quantitatively and easily measurable.

Permanence

Biometric characteristics are permanent; it should be invariant with time.

Acceptability

Negative associations using a particular biometrics are usually undesired and users must be willing to accept and use the system.

Circumvention

It should be impossible for intruders to defraud the biometric system.

Even though Fingerprint based authentication technique is very fast, reliable, inexpensive and easiest way to recognize an individual; person working in chemical, mechanical or metal industries may not have legible fingerprint, also person who undergo physical disorder like accidents may also suffer from fingerprint based authentication system. To overcome this negative impact in the area of fingerprint based unimodal biometric system, a multimodal biometric system which combines fingerprint and retina for authentication is proposed since Fingerprint Based Multimodal Biometric system in more efficient than any other multimodal biometric system. Retina is a internal protected organ of body which is placed inside the eye of an individual consist of unique pattern of blood vessels which does not change through the life time.

Fingerprint is an Impression or mark left by the friction ridge of a human fingertip, which is used for identifying individuals. Human fingerprints are unique, difficult to alter, and durable over the life of an individual, making them suitable as long-term markers of human identity. Fingerprint feature includes overall flow pattern, frequency of ridge, position and location of singular points, location, type and direction of minutiae, no of ridge between pair of minutiae, location of pore etc. These features are generalized as texture feature and minutiae feature.

RELATED WORK

Lin et.al proposed alignment based elastic matching algorithm for minutiae matching in fingerprint based authentication system[2]. Texture features of Energy, Local Homogeneity,

Entropy and Inertia obtained from fingerprint using SGLDM eliminates the problem of missing or false minutiae. This method also deals with non-uniform shape distortion problem[3]. Bartunek et al (2013) proposed a contextual filtering based adaptive fingerprint enhancement technique for fingerprint biometric based authentication. The proposed method is insensitive to the various characteristics of the fingerprint images obtained by different sensors[4]. A fingerprint based Voting system is designed using minutiae features. This voting system pursues Threshold based Cryptographic Technique followed by compression [5]. Annapoorani et.al proposed crossing number method to locate the boundary and minutiae matching is done by storing the extracted data in matrix form [6]. An efficient authentication system using skelteonization and similarity transformation is proposed. Hessian based vessel segmentation method is used to extract the complete retinal vessel. Skeletal structure is constructed using skeletonization. Apply pixel classification method on the skeletal structure to extract the bifurcation points[7]. Wafa et.al proposed a identification system by constructing two feature vectors by utilizing angular and radial partitioning. During decision making phase establish manhattan distance for each and every image and identify an individual using fuzzy system[8]. An automated person identification based on vasculature pattern of retina is proposed in the literature. The system first extracts the Vasculature pattern of retina using Gabor wavelet and multilayered thresholding technique. Estimate Feature Distance by using mahalanobis distances between feature points of stored retina and query image. Based on the estimated Feature Distance the person is accepted as genuine or rejected as imposter [9]. Suganya et.al apply visual cryptographic technique to on retina for user authentication. Retinal features are extracted by convolving the normalized retina into 1D wavelet transform. Stored template in hidden by applying visual cryptography a secret key sharing scheme[10]. Pouya et.al proposed a novel method based region based shape features, boundary based shape features and Weighted Corner Angle feature using hierarchical Matching structure for person authentication[11].

A Multimodal Biometric Authentication based on minutiae features of fingerprint and retina is proposed in the literature. The information obtained from the biometric traits undergo feature level fusion. Feature fusion is a technique which combines the minutiae features obtained from the biometric traits namely fingerprint and retina. Clustering is introduced to obtain more optimized result[12]. A Multimodal Biometric Authentication system based on fingerprint, iris and retina is designed for network security. The system use feature level fusion to fuse the information obtained from different modalities. Generate a Cryptographic key from the fused feature, this technique is more secure [13]. Jagadiswary et.al proposed multimodal Biometric system based on fingerprint, retina and fingervein for authentication . Extracted features are stored as a matrix for further processing. Secret key generated using RSA is used to secure the stored template [14]. Muthukumar et.al proposed multimodal biometric authentication system based on fingerprint and finger knuckle print. The multi resolution feature of fingerprint extracted using Discrete Wavelet Transform and key features of finger knuckle print features extracted by scale Invariant feature transform are Clustered using K-Means Clustering and the data are fused. These fused data is stored in database for authentication[15].

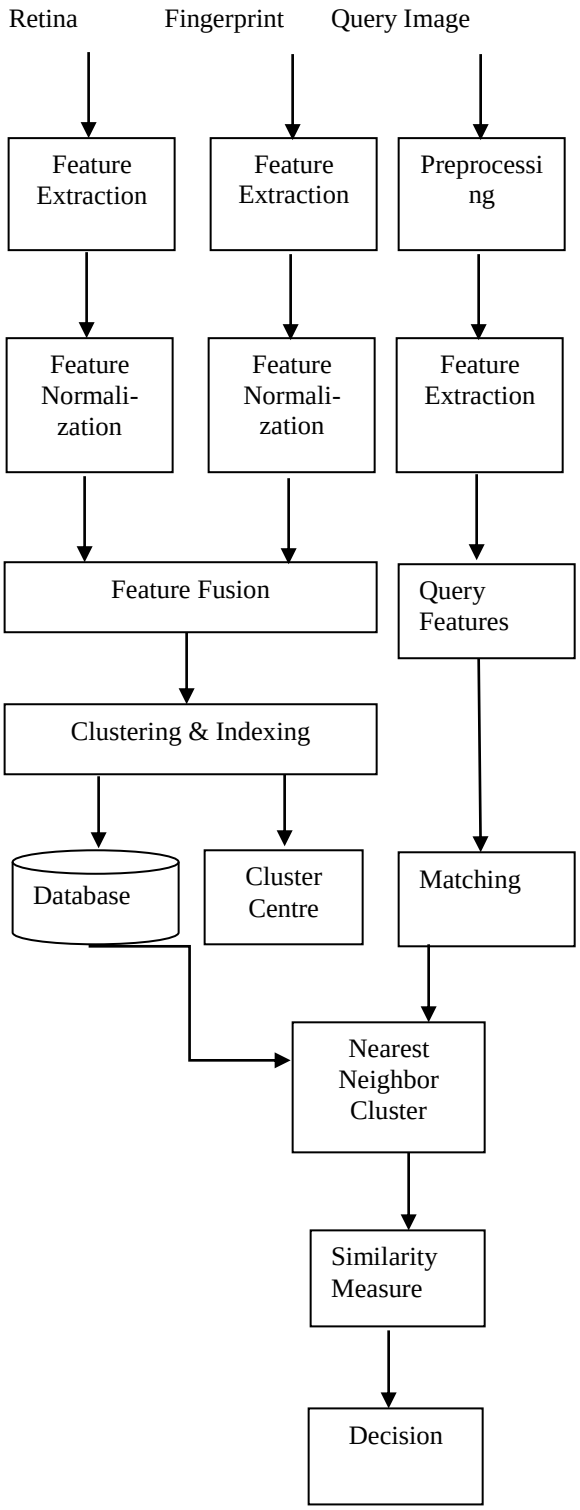

Figure 1. Proposed Multimodal Biometric System

Multimodal Biometric based verification system using fingerprint, iris and voice is proposed in the literature to access control of locker[16]. Multimodal Biometric based security system using palmprint and voice biometric system based on Fuzzy decision level fusion is proposed. The system extracts palmprint features using Gabor wavelet and Local Binary Pattern and voice features using MFCC and Hashing technique. The features are fused using AND and OR rules based on fuzzy decision level fusion[17]. Multimodal Biometric based security system using palmprint and voice biometric system based on Fuzzy decision level fusion using Surgeon approach is used for authentication[18].

PROPOSED METHODOLOGY

This paper proposes the multimodal Biometric system by integrating minutiae features of fingerprint and retina. The Proposed Multimodal Biometric system is given in fig 1. The minutiae features are extracted from both the fingerprint and retina. Feature level fusion is a technique which combines the information obtained from various biometric traits for authentication. One technique used for feature level fusion is concatenation which may increase the time complexity. To overcome this disadvantage we go another technique namely clustering. This paper proposed K-Means Clustering with Indexing. Fig1. Shows the proposed Multimodal Biometric System.

Fingerprint

In fingerprint the point where the ridge line terminates is termed as minutiae. Minutiae can be characterized as ridge dots, ridge ending, ridge islands, ridge Enclosure, ridge bifurcation, ridge ponds, ridge spurs, ridge bridges and ridge crossover as shown in Fig 2. Minutia-based techniques not vary because they are robust to geometric transformation like rotation, translation etc. Fig 3 shows fingerprint minutiae before and after post processing.

Preprocessing

Preprocessing includes image enhancement, image binarization, and Image segmentation. Image Enhancement is the initial process used to remove noise from the given input image. Enhancement can be done using histogram equalization. Binarize the resultant image using adaptive binarization technique. Segment the ROI from the fingerprint. ROI can be extracted by estimating the direction of the block and applying morphological Open operation and Morphological Close operation

Minutiae extraction

Minutiae extraction includes Ridge Thinning, Ridge Enhancement, Minutiae Marking. Ridge Thinning is morphological operation performed on Binary image to reduce the width fingerprint line to 1 pixel wide. Ridge enhancement eliminates the erroneous pixels and preserves the skeleton connectivity. Concept of Crossing number is used to perform Minutiae Marking.

Post processing

Post processing is the important step in fingerprint minutiae extraction. Flase Minutiae Removal and Minutiae Matching is performed during this stage.

Retina

Minutiae points are extracted from the Blood vessels of the Retina. So Blood Vessel extraction is the First and foremost step in minutiae extraction form retina.

Preprocessing

Preprocessing is a technique used to improve the quality of the retinal image. During this stage Adaptive histogram equalization is used for retinal image enhancement, noise removal is done using Median filtering.

Optic Disc Detection and Removal

Use Morphological close operator to remove small holes in the preprocessed image, Otsu threshold method is applied to find a threshold, perform dilation. Remove the Optic disc from the preprocessed retinal image.

Blood Vessel extraction

First the gray scale image is converted to binary, then apply median filtering. Remove the smaller area components and extract largest blob area which is the Blood Vessel.

Feature Extraction

Among various landmarks of retina ridge ending and Bifurcation ending are extracted as minutiae features from the Retinal Blood vessels.

Feature Level Fusion

Feature level fusion is a technique used to combine the minutiae features obtained from the biometric traits namely fingerprint and retina. One technique used for feature level fusion is concatenation which may increase the time complexity. To overcome this disadvantage we go another technique namely clustering and Indexing.

K-Means Clustering:

$X = \{x1,x2,x3,\ldots\ldots..,xn\}$ be the set of data points and

$V = \{v1,v2,\ldots\ldots.,v10\}$ be the set of centers.

1) Randomly select *'c'* cluster centers.
2) Calculate the distance between each data point and cluster centers.
3) Assign the data point to the cluster center whose distance from the cluster center is minimum of all the cluster centers..
4) Recalculate the new cluster center using: where, *'ci'* represents the number of data points in i^{th} cluster.
5) Recalculate the distance between each data point and new obtained cluster centers.
6) If no data point was reassigned then stop, otherwise repeat from step 3).

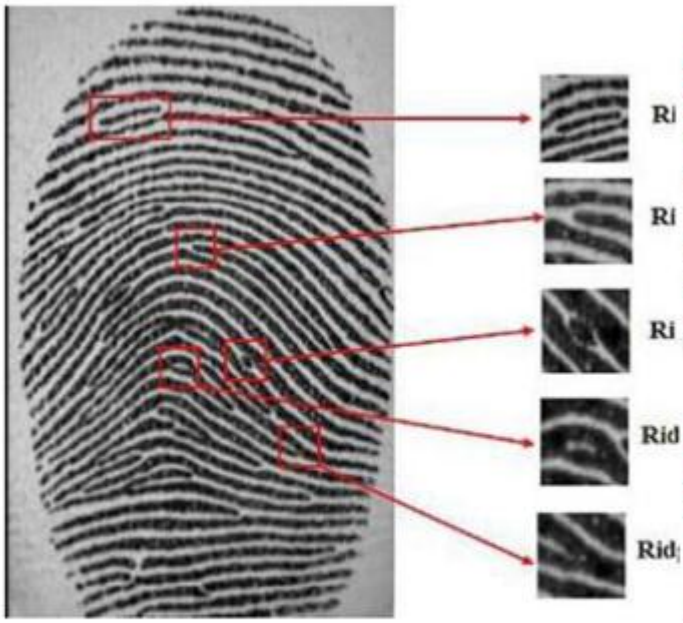

Figure 2. Common Fingerprint Minutiae Points

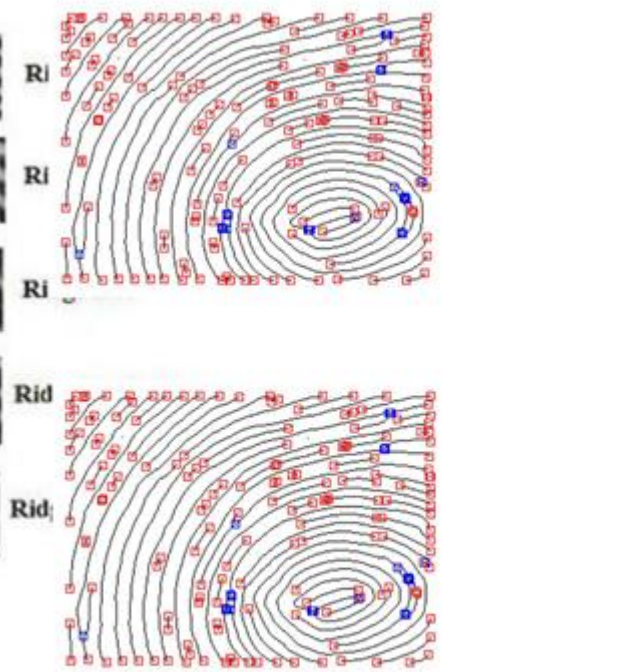

Figure 3a. Fingerprint minutiae before post processing
b. Fingerprint minutiae after post processing

Indexing

Indexing assigns an index value to each and every clusters. For each and every clusters estimate the cluster center. During Authentication phase Query feature is matched with the existing Cluster centre and obtain all the nearest neighbor cluster between the Database and the obtained feature. Similarity Measure is estimated using Euclidian distance. Based on the similarity measure the user is accepted as genuine or rejected as imposter. Here the Query image is only matched among the retrieved identity which reduces the time and error rate.

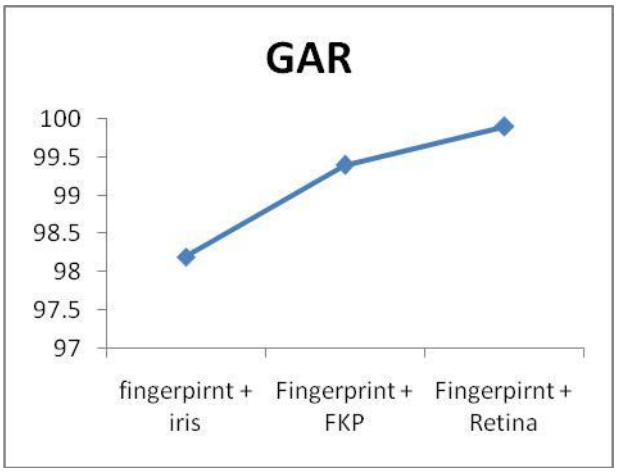

Figure 4. GAR Comparison of Existing Multimodal Biometric System with the proposed

EXPERIMENTAL RESULTS

Experiments are conducted using the FVC2004 fingerprint database and STAR and DRIVE retina database. Analysis of the proposed system is compared with the existing system based on False Acceptance Rate (FAR), False Rejection Rate (FRR) and Genuine Acceptance Rate (GAR) and Accuracy. Fig.4 , Fig.5, and Fig. 6. shows the Comparison of proposed Multimodal Biometric System using feature level fusion and K-Means Clustering with Existing

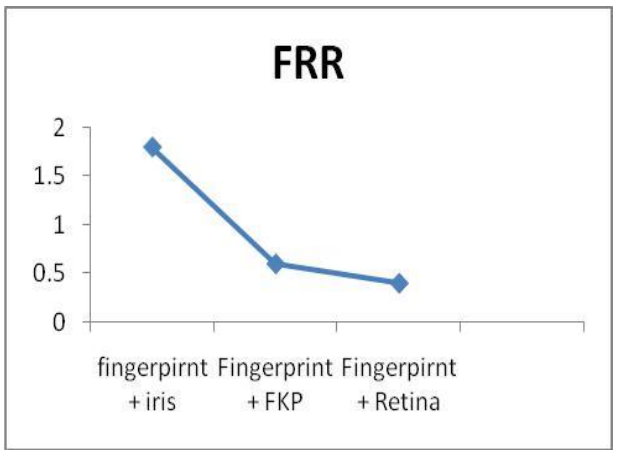

Figure 5. FRR Comparison of Existing Multimodal Biometric System with the proposed

CONCLUSION

This paper presents a method of multimodal biometric systems based on minutiae features of fingerprint and Retina. The minutiae features acquired from fingerprint and retina undergo feature level fusion. To get a more discriminate feature the futures are clustered into clusters with indexing and stored in database. During authentication phase features of the query image in matched with the features present in the database and based on the similarity measure the person in the spot is accepted as genuine or rejected as imposter. This proposed multimodal biometric provides authentication with GAR = 99.97%, and FRR = 0%. These results are obtained using FVC fingerprint database and STAR and DRIVE Retina Databas

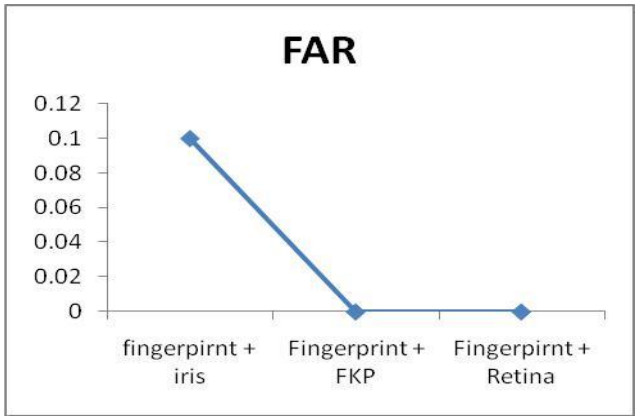

Figure 6. FAR Comparison of Existing Multimodal Biometrics with the proposed

CONCLUSION

This paper presents a method of multimodal biometric systems based on minutiae features of fingerprint and Retina. The minutiae features acquired from fingerprint and retina undergo feature level fusion. To get a more discriminate feature the futures are clustered into clusters with indexing and stored in database. During authentication phase features of the query image in matched with the features present in the database and based on the similarity measure the person in the spot is accepted as genuine or rejected as imposter. This proposed multimodal biometric provides authentication with GAR = 99.97%, and FRR = 0%. These results are obtained using FVC fingerprint database and STAR and DRIVE Retina Database.

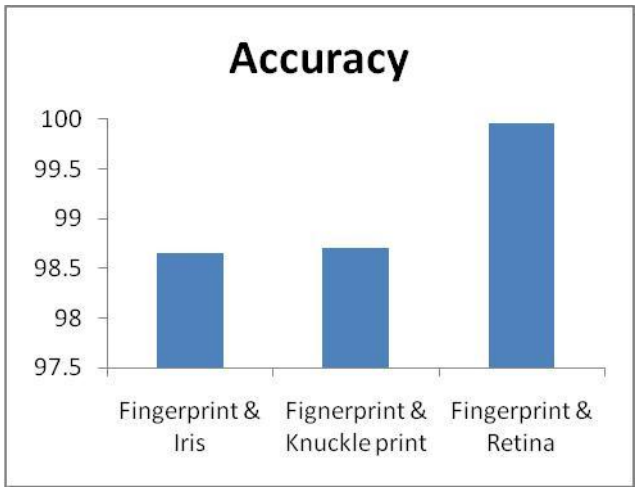

Figure 7. Comparison of Accuracy of the Existing Multimodal Biometric System with the proposed

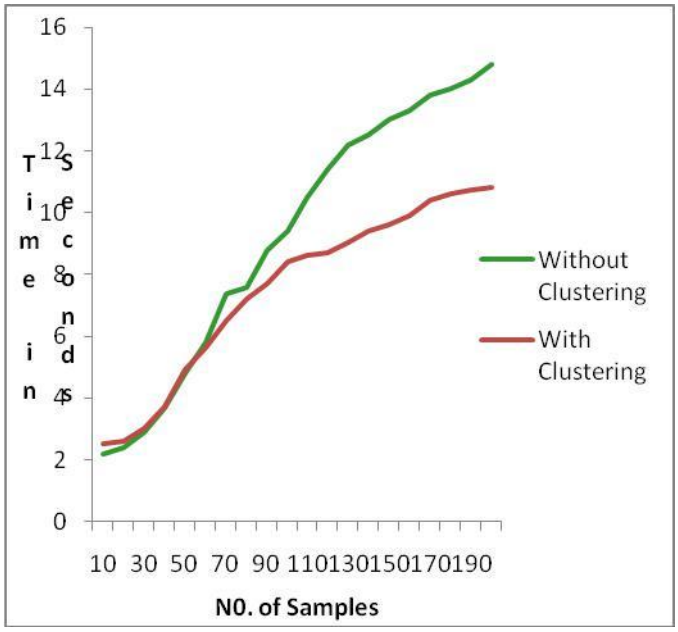

Figure 8. Comparison of Execution Time for Authentication Phase with and without Clustering

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