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Finger Vein Detection using Repeated Line Tracking, Even Gabor and Multilinear Discriminant Analysis (MDA)

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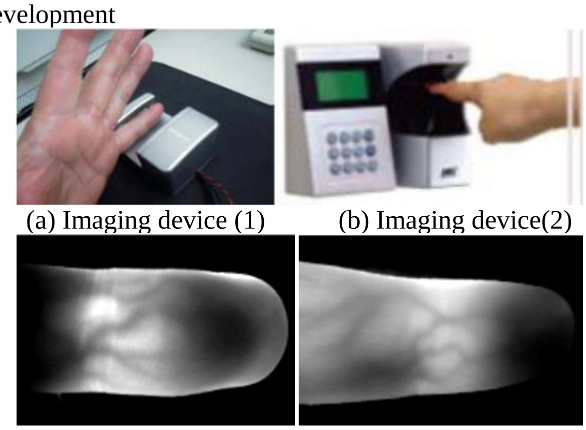
Abstract—Finger vein detection is a physiological characteristics-based biometric technique, and it uses vein patterns of human finger to perform identity authentication. Even in the case of identical twins the finger-vein patterns are believed to be quite unique [1]. Moreover finger vein has many more advantages as compare to other biometric system as result its application area becoming wider day by day. In this paper, following techniques are analyzed i.e., Repeated Line Tracking, Gabor Filter and Multilinear discriminant analysis (MDA). Both Repeated Line Tracking, Gabor Filter are efficient method for feature extraction but, combination of these two techniques with MDA Classifier increases the performance and average accuracy as compare to existing systems. In proposed work some important parameters like Peak Signal to Noise Ratio (PSNR),MSE,Genuine Acceptance Rate (GAR) and False Acceptance Rate (FAR) are calculated for Performance evaluation. When tested on a finger vein images database this system provides more accurate results and it is less time consuming as compared with existing.

Keywords:- Finger vein, biometric system, Feature extraction, Repeated Line tracking, Gabor filter, classifiers, Multilinear discriminant analysis(MDA).

I. INTRODUCTION

Personal identification technology is applied to a wide range of systems including controlling access, computer login, and e-commerce. Biometric techniques usage for person detection have been attracting a lot attention these days as compare to conventional means like passwords, security keys, and PIN numbers. In the area of biometric identification, security and convenience of the system are important [1]. In particular, these systems require high accuracy and fast time response. Many biometric based methods such as fingerprints [9– 11], facial features, the iris, the voice, the hand geometry, or the veins on the back of the hand are present. However, these methods do not necessarily ensure confidentiality because the features used in the methods are exposed outside the human body. This may result in forgery in these methods. To reduce these issues, biometric system using patterns of veins within a finger, that is, patterns inside the human body is proposed [2,3].

This technology of finger vein identification is very impressive because it requires relatively cheap small and single-chip design, has a fast identification process and has higher accuracy when compared with other identification biometrics like fingerprint, iris, facial and others[9]. This higher accuracy rate of finger vein is not only with the fact that finger vein patterns are virtually impossible to forge and has many more countable benefits including its design moreover, is contactless which means not direct contact with device hence more hygienic as a result it has become one of the fastest growing new biometric technology that is quickly finding its way from research labs to commercial development



(a) Imaging device (1) (b) Imaging device(2)

(c) Finger vein image (1) (d) Finger vein image (2)

Fig.1 Prototype of finger-vein imaging device (a, b) and examples of infrared images of a finger (c, d)

Finger Vein proved that each finger has unique vein patterns so that it can be used in personal verification. To get the vein pattern, a person inserts a finger into an attester terminal containing a near-infrared LED light and a monochrome CCD camera as shown in fig.1. The hemoglobin in the blood, absorbs the closer infrared light rays, the pattern of veins in the palm side of the hand of finger is captured as a pattern of shadows, which makes the vein system. The camera records the digitized raw data and the image, and sent it to a database of registered images. The finger is scanned as before and the data is sent to the database of registered images for authentication purposes which takes less than two seconds [6].

Many feature extraction techniques were developed for example, Miura et al proposed a finger vein extraction method using repeated line tracking [4]. Song et al. used the mean curvature method, which considered the vein image as a geometric shape and then use negative mean curvatures for located the valley-like structures of veins [6]. These methods have good performance but under the assumption that the blood vessel networks are properly segmented.

However, due to the low quality of finger vein image occurs due to optical blurring and skin scattering problems segmentation errors may occur during the feature extraction process Moreover, the accuracy of vein segmentation is easily affected by the image translation, rotation, scale, and uneven illumination. Hence, recognition performance using these methods will be degraded when the networks are not segmented properly.

Ajay Kumar et al proposed human identification system which simultaneously acquire finger-vein and finger surface (texture) images is presented [1]. Moreover to overcome above problems, the steps for the acquired finger-vein image normalization, rotational alignment, and segmentation to effectively minimize resulting intra class variations in the finger images are also developed. However this system reduce the problem of rotation and segmentation but pattern matching cost and time of this system is not efficient.

In proposed system problem of pattern matching time is reduced with use of tensor based classifier Multilinear discriminant analysis(MDA) which categorizing the finger-vein images to different classes based upon dimension along with feature extraction methods that are Repeated Line tracking, even Gabor filters and even Gabor with morphology. Problem of noisy image, translation rotation variance, enhancement, and uneven illumination is solved by preprocessing as discussed in section II**.** With use of Automatic trimap generation problem of image segmentation is solved.

II. Block Diagram Of Proposed Work

The block diagram of the proposed system is shown in Figure

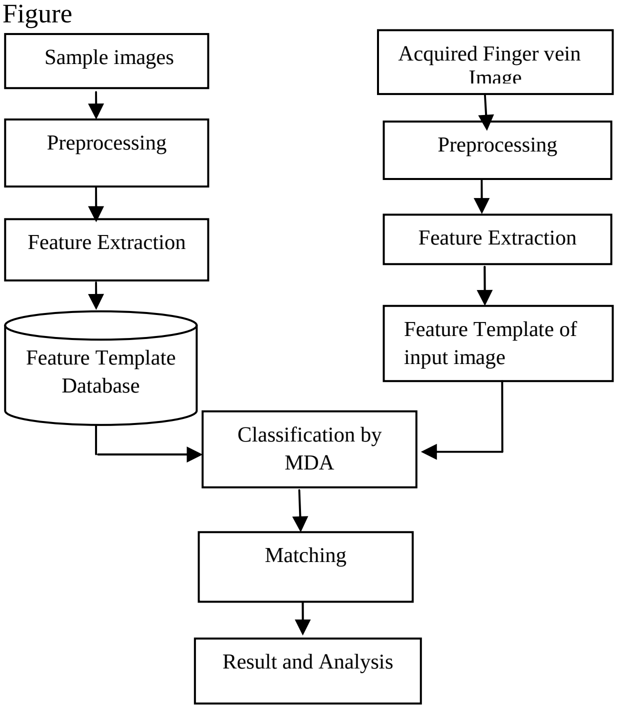


Fig 2: Block diagram of proposed system

Image Acquisition:- Image acquisition means acquiring an image from the source stored in some hardware or from direct source**.** Finger vein image acquired is captured by device containing a near-infrared LED light and a monochrome CCD camera as shown in Figure.1. In image acquisition the browse image is loaded for further processing shown in figure 3.

Preprocessing:- The second step of proposed system is pre-processing. This step is important as acquired image is noisy. The pre-processing includes series of operations performed on acquired input finger vein image. These steps are mentioned below:

1) Image Binarization: Each of the acquired finger-vein images is first subjected to binarization . A binary image is a digital image that has only two possible values for each pixel i.e. 1 and 0.Using a fixed threshold value, to coarsely localize the finger shape in the images.

2) Edge Detection: After binariztion, remaining isolated and loosely connected regions in the binarized images are eliminated in two steps: Firstly, the Sobel edge detector is applied to the entire finger vein image, and the resulting edge map image is subtracted from the binarized image. Subsequently, the isolated blobs (if any) in the resulting images are eliminated from the area thresholding, by the elimination of number of connected white pixels being less than a threshold.

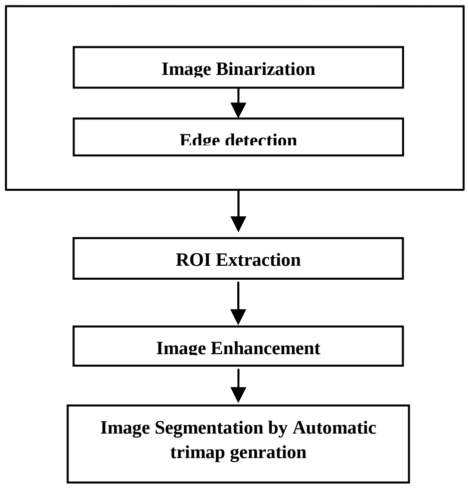


Fig 3: Block diagram of preprocessing steps

3. ROI Extraction: ROI (REGION OF INTEREST) is used to get only important region of a finger vein image, by elimination unwanted background details, as result less time is consumed in processing. The resulting binary mask obtained from above step is used to segment the ROI from the original finger-vein image. Output of this step is shown in figure4.

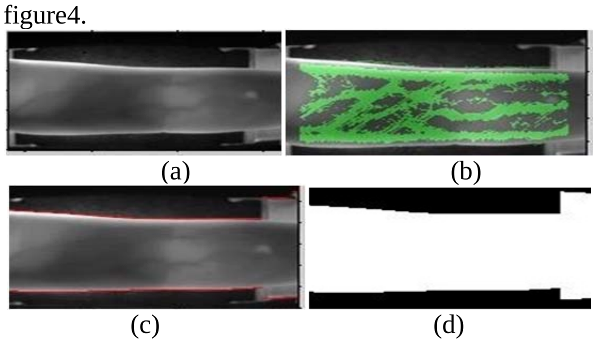
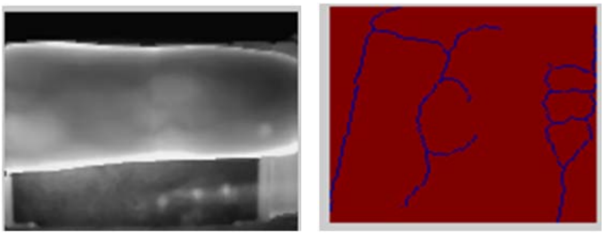


Fig4: Extraction of ROI from finger vein images. (a) Acquired image sample (b) Binarized image. (c) Edge map subtracted from (b). (d) ROI mask from the image in (c) and the ROI finger vein image.

4. Image Enhancement: It is the process of improving the quality of a digitally stored image .As the image got damaged or its quality decrease during the process of clicking the image or transferring the image, the image enhancement is done to improve the image quality. [19] Therefore, the finger vein images with uneven illumination and low contrast are subjected to nonlinear image enhancement [1]. In proposed work Median filter is applied. Median filtering is a nonlinear operation based filter which used in processing of image to reduce noise (i.e. salt and pepper noise). A median filter is more effective as compare to convolution when the goal is to simultaneously reduce noise and preserve edges. Enhanced image is shown in fig:3.

5. Image Segmentation: It is difficult to extract precise details of the image because of the irregular noise and shades around the finger-vein hence segmentation is done to resolve this. The Automatic Trimap Generation is used to achieve good segmentation performance for low quality images of finger-vein [19].



(a) (b)

Fig: 5 (a) Enhanced Image, (b) Segmented Image by automatic trimap generation

Feature Extraction: - Transforming the input data into the set of features is called feature extraction. The feature extraction is process of extracting the features like thickness, length and shape of the vein pattern. The three methods or techniques are used to extract the features are Repeated Line Tracking, Even Gabor filter and Even Gabor with morphology.

Classification: The main objective of image classification is to automatically categorize all pixels in an image into land cover classes or themes. The term classifier may refer to a computer program that implements specific procedure for image classification. The system efficiency over a large database should not be negligible in the real situation. So, categorization of the finger-vein images to different classes is helpful for reducing pattern matching cost. In Proposed work classifier based on discriminant analysis is used that is Multilinnear discriminant analysis (MDA). Classification helps in speed up matching operations and enhances the overall performance. Output of classification is stored in database as template and these templates are processed during matching.

Finger Vein Matching: - The output come from all the previous steps will be matched with the data stored in the database, which shows whether the acquired vein is matched or not. In this part, the extracted feature will match with the enrolled features in the feature database. Here SURF (speed up robust feature) is used for matching vein pattern. The SURF has better speed and accuracy as it uses object reorganization feature. All features of vein images are stored in database [7].

Database: To test the performance of the proposed method, the finger vein images are stored in database. The captured images comprise of finger veins that are 8-bit gray images with a resolution of 320 *240. In proposed system work is done only on index finger vein images. The acquired finger-vein images are not high in quality hence, need processing. Database images and input image processed vein patterns (finger vein templates) are stored in the database. These templates are access by classifier for classification and for matching.

III. METHODOLOGY

The following are the methodologies used in proposed work for implementing finger vein detection;

1) Repeated line Tracking:

Repeated line tracking method gives a promising result in finger-vein identification [1, 3].Line tracking starts randomly at different positions. To find the dark line line tracking executed by moves along the direction of vein pattern pixel by pixel. The idea is to trace the veins in the image by chosen directions according to predefined probability in the horizontal and vertical orientations, and the starting position, called seed is randomly selected; the whole process is repeatedly done for a certain number of times [3].

Steps involve in Feature extraction using repeated line tracking:

Step 1: Determination of the starting point for line tracking and the moving-direction attributes.

Step 2: Detection of the direction of the dark line and movement of the tracking point

Step 3: Updating the number of times points in the locus space have been tracked

Step 4: Repeated execution of step 1 to step 3 (*N* times)

Step 5: Acquisition of the finger-vein pattern from the locus space

Advantages of repeated line tracking:

1) Reduce the computation time: Repeated line tracking reduce unnecessary tracking operations which result in faster processing and reduce the computation time.

2) Reduce size of pattern: Repeated line tracking reduces the size of locus space result in fast response as smaller the template, the faster the computation [3].

2) Even Gabor filter:

Gabor filter, is a linear filter used for edge detection. Its frequency orientation representation is similar to those of the human visual system; and they have been found to be particularly appropriate for texture representation and discrimination. Hence in spatial domain; a 2D Gabor filter is a Gaussian kernel function modulated by a sinusoidal plane wave [1][5]. Gabor filters: are self-similar, which means, all filters can be generated from one mother wavelet by dilation and rotation [10].Its impulse response is defined by a Gaussian function multiplied by a harmonic function. These filters have been shown to posses optimal localization properties in both frequency and spatial domain. And thus are well suited for texture segmentation problems. Gabor filter can be viewed as a sinusoidal plane of particular frequency and orientation [1], modulated by a Gaussian envelope.

$$G(x, y) = s(x, y)\, g(x, y) \qquad (1)$$

Where g(x, y) is 2D Gaussian envelope and (x, y) is complex sinusoid.

The analytical form of 2-D even Gabor filters in the spatial domain can be expressed as:

$$h(p)_\theta = \frac{1}{2\pi|c|^{1/2}} \cos \omega_m^T (p_n - p_o) * \exp[-\frac{1}{2}(p_n - p_o)^T c^{-1} (p_n - p_o)]^T \qquad (2)$$

Where p, p_o, $\omega_m \in R^2$; C is a 2 2 positive definite covariance matrix; and |C|=detC . The horizontal and vertical spatial coordinates are represented by vector $P=[x, y]^T$, whereas vector $P_o=[x_o, y_o]^T$ stands for the translation of origin. However, the spatial modulation frequency ω_m is only in one direction as in proposed work use the Gabor filters is use to detect width and length [1].

(a) (b).

Fig6: Shows output feature extraction techniques, (a) Output of Repeated Line tacking, (b) Output of Even Gabor Filter.

3) Even Gabor Filter with morphology:

For further enhancement and the clarity of vein patterns morphological operation are combined with even Gabor filter. The morphological operations typically are of low computational complexity and compare a vein image with another known object, i.e., a structuring element. For the purpose of object detection and noise elimination the shape and size of the structuring element are chosen from a priori knowledge [1]

4) Multi-linear Discriminant Analysis (MDA):

It is Dimensionality Reduction-based Methods in which multiple interrelated subspaces can collaborate to discriminate different classes. Subspace learning methods usually transform image into low-dimensional space to classify. In transformation, they keep discriminating information and remove noises [5]. MDA is a transformer that enhances class separability in the tensor space, before making the final decision. In transformation, they keep discriminating information and remove noises. The classification effort may require preparatory processing prior to classification so image under goes preprocessing as discussed in section II.

Various advantages of MDA:

1) The MDA algorithm can avoid the curse of dimensionality and serves the small sample size problem.

2) The computational cost in the learning stage is reduced.

3) The extension from vector to tensor for data representation and feature extraction is general and it can also be applied on SVM and many other algorithms to improve algorithm learn ability and effectiveness [18].

IV. Results And Discussions

A starting GUI was created to perform all the five operations that is browse input image, process input image, create or add images in database, process database and match. While matching the processed image with stored image six parameters are calculated that is its PSNR value, FAR and GAR, MSE, Accuracy and its Computation time.

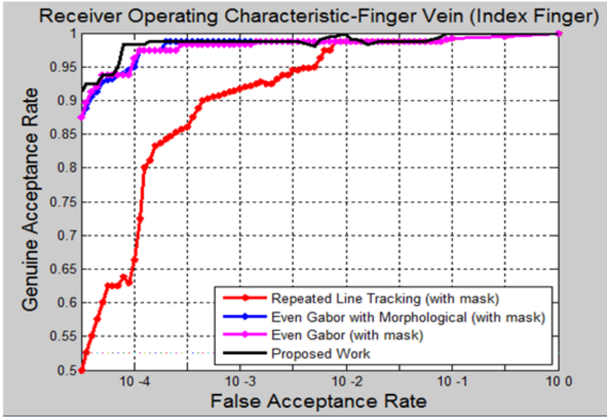


Fig7: Receiver Operating Characteristic-Finger Vein between GAR and FAR

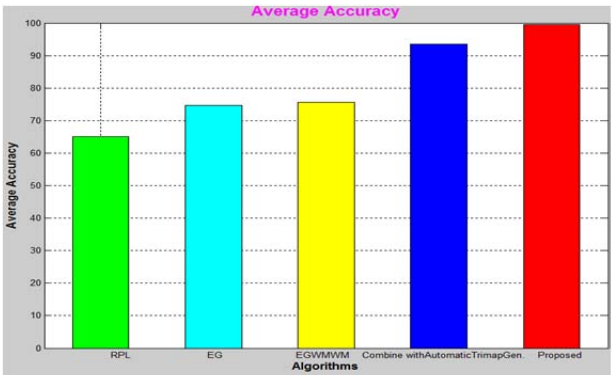


Fig8: Graph showing comparison of Average accuracy values between various algorithms and Proposed Algorithm

Table 1: Comparison of average accuracy

	TECHNIQUES	AVERAGE ACCURACY (%)
1	Proposed Work	99.50
2	Repeated Linetracking (RPL)	64.9939
3	Even Gabor(EG)	74.5930
4	Even Gabor With Morphology(EGWM)	75.6930
5	Cobinnation Of RPL, EG and EGWM With Automatic Trimap Generation	93.5030

Table2: Comparison of PSNR values between various techniques and Proposed Work

SNO	TECNIQUES	PSNR(db)
1	Proposed Work	49.6341
2	Repeated Line Tracking (RPL)	15.0270
3	Even Gabor (EV)	24.6441
4	Even Gabor With Morphology(EGWM)	25.8171
5	Combination Of RPL, EG and EGWM With Automatic TRIMAP GENERATION	40.5141

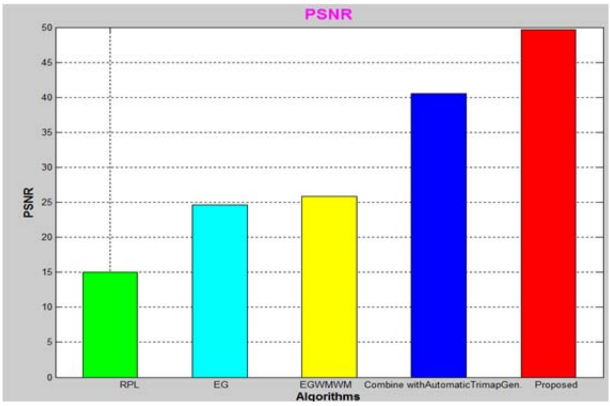


Fig9: Graph showing comparison of PSNR values between various algorithms and Proposed Algorithm

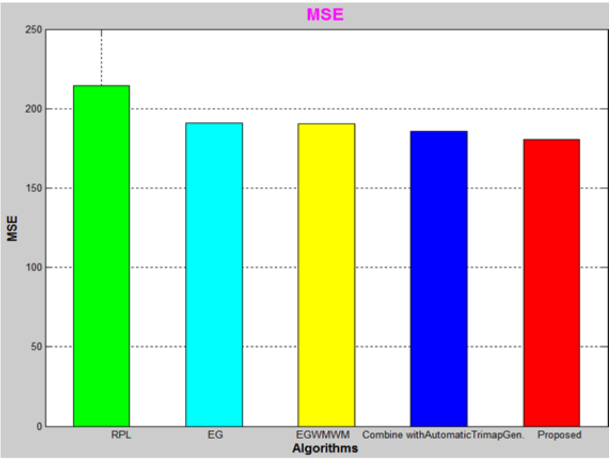


Fig10: Graph showing comparison of MSE values between various algorithms and Proposed Algorithm

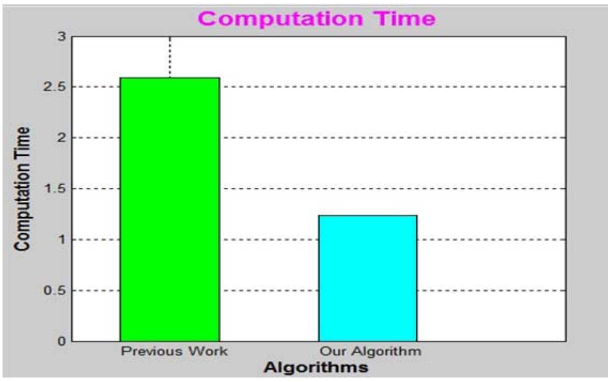


Fig11: Graph showing comparison of Computation Time between Previous Work and Proposed Algorithm

V. CONCLUSION

In this paper, a finger vein detection system based on MDA has been presented. The proposed approach contains several phases, namely, image acquisition, preprocessing, feature extraction, classification and matching. The system has been implemented in MATLAB with real images.

In past there is work done by Repeated Line Tracking approach and Gabor filter approach individually but the combination of these two approaches with Multilinnear discriminant analysis (MDA) as Classifier is not done before. As shown, the presented new algorithm for the finger-vein detection is more reliably extracts the finger-vein shape features and achieve much higher accuracy than previously proposed finger-vein identification approaches. The proposed method also has better ROC and makes the lower MSE and high PSNR which result in reducing the matching cost as well as improving computation time along with the accuracy of finger-vein detection. Computation Time of proposed algorithm is **1.8700sec.**

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