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# Secure User Authentication Based on Finger Vein Patterns

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***Abstract*— Biometrics is one of the highly accurate technologies in the field of user identification. Finger vein recognition is amethod of biometric authentication that uses pattern recognition techniques based on images of human finger vein patternsbeneath the skin's surface. It is more secure than various other biometric traits like palm prints, voice, iris, face fingerprint etc because, finger vein patterns cannot be forged like the others. Various steps for user identification using finger vein patterns includes acquisition of finger vein image, preprocessing of image, extraction of relevant features and finally pattern matching. A methods efficiency can be measured with the help of measuring its Accuracy and Precision.**

***Keywords*— Biometrics, authentication, Finger Vein recognition, Accuracy, Precision**.

## I. INTRODUCTION

Biometrics is a set of technologies based on measurement of some unique characteristics of an individual for the purpose of identification. Biometric is considered to be the most convenient and secure authentication technology. It cannot be borrowed, stolen or forgotten and upto a limit forging is practically impossible. This technology measures individual's unique physical or behavioural characteristics to recognize their identity. Physical biometric characteristics include fingerprints, hand geometry, retina, iris and facial identity.

Behavioural characters include signature, voice, keystroke analysis and gait. [1] briefly explains about different biometric traits and their scope in the field of authentication. Many biometric traits are nowadays not commonly used like signature recognition, voice identification etc because both of the above said traits can be forged. [2] explains about usage of fingerprint as a tool for person identification. In that paper usage global and local features of fingerprints are used. [3] briefly compares various iris recognition algorithms. Those algorithms are based on iris codes, zero crossings etc. [4] explains palmprint authentication system using wavelet transforms. Here color parameters of palm print are changed to HSI parameters because gray scale images retain all useful information required for personal identification. [5] explains iris recognition using artificial neural networks. Here for pre-processing feed forward artificial neural networks trained by back propagation algorithm is used.

The above mentioned biometric traits are having some disadvantages like facial recognition is affected by changes occurring in lighting, the hair of a person, the age, and if the person wear glasses etc, fingerprints and palmprints can be frayed usually, voice, signatures etc are less accurate and can be easily forged, iris images based identification are highly intrusive etc.Fingervein is a promising biometric pattern for personal identification in terms of its security and user convenience. The vein is hidden inside our body. It is almost invisible to human eyes.

Forging in this case is very difficult. User authentication based on finger vein pattern is more acceptable because of its hygiene nature. These patterns can be taken only from a person whose is alive. So it is a convincing proof that the person whose finger vein image is captured is alive. Various steps for user authentication based finger vein pattern includes image capturing, preprocessing of captured image, vein feature extraction and feature matching. As vein is present beneath the skins surface, for capturing its image, near infrared light is passed through the fingers. Human tissues blocks most of the rays. But hemoglobin in blood absorbs them. So in the captured image vein portions appears much darker than surrounding areas. For user authentication vein features are extracted and stored in template for future use.

## II. EXISTNG METHODS

The paper [5] explains that protection of personal information in today's world is of very importance.Finger Vein is a promising biometric pattern gaining popularity as vein is hidden inside and is invisible to human eyes and is difficult to forge or steal and also it is hygiene and also it can be taken only from a live body, so it is a natural and convincing proof that the person whose vein is being taken is alive. Here finger vein images are captured and then segmentation and alignment and enhancement is done for extracting features and then a template is made of features and when a matching is to be done the entered feature after the above mentioned steps is compared with feature from the template. If matched, user is accepted to be the original one, else rejected.

In [8], it is mentioned that to identify a person with high accuracy, the pattern of the thin/thick and clear/unclear veins in an image must be extracted equally. The pattern should be extracted with little or no dependence on vein width and brightness fluctuations. Here a new method is proposed by checking only the centerlines of veins.

The paper [2] mentions about the two problems commonly found in finger vein authentication. One is that the quality of the vein image will be reduced under bad environment conditions; the other is the irregular distortion of the image caused by the variance of the finger poses. Here a wide line detector for feature extraction and a new pattern normalization model based on a hypothesis that the finger's cross sections are approximately ellipses and the vein that can be imaged is close to the finger surface are explained. It can effectively reduce the distortion caused by the pose.

In the paper [14], explains that with the development of technology, powerful consumer devices such as laptop, cell phone,PDA etc have raised the level of flexibility and user convenience .Protection of personal information in these in these devices from theft or misuse is becoming a major issue. As a solution to this, in this paper a finger vein recognition algorithm based user identification framework is described. The algorithm uses Radon Transform and SVD(singular value decomposition) for feature extraction and classification is done using a normalized distance measure.

In [9], propose a method of user identification based on finger vein patterns. A finger vein image captured by passing infra red light through fingers contains not only vein patterns but also irregular shading due to varying thicknesses of finger bones and muscles. So for accurate and precise user identification vein features are to be extracted out of the captured image.For that a repeated line tracking which starts from various positions in an image is used.

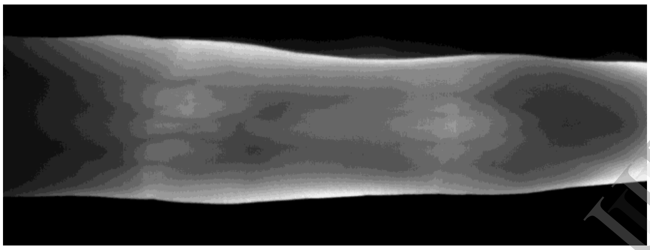

Fig 1. Raw finger vein image captured by camera

## III. OBSERVATIONS & INFERENCES

TABLE 1. COMPARISION OF VARIOUS FINGER VEIN RECOGNITION METHODS

| **Method** | **No : of Images used** | **EER (%)** |
|---|---|---|
| Repeated Line Tracking[9] | 678 | 0.145 |
| Max Curvature without Normalization[8] | 678 | 3.86 |
| Max Curvature with Normalization[8] | 678 | 2.80 |
| Wide Line Detector without Normalization[2] | 50,700 | 2.86 |
| Wide Line Detector with Normalization[2] | 50,700 | 0.87 |
| Extraction based on Lacunarity[5] | 600 | 0.07 |

## IV. DATABASE USED

The database used in this paper is from the Group of Machine Learning and Applications, Shandong University [7] .This is the first open database made available for research purposes. The database is named SDUMLA-HMT.It is a Homologous Multi-modal Traits Database which includes real multimodal data from 106 individuals. The device designed by Joint Lab for Intelligent Computing and Intelligent Systems of Wuhan University was used to capture finger vein image.

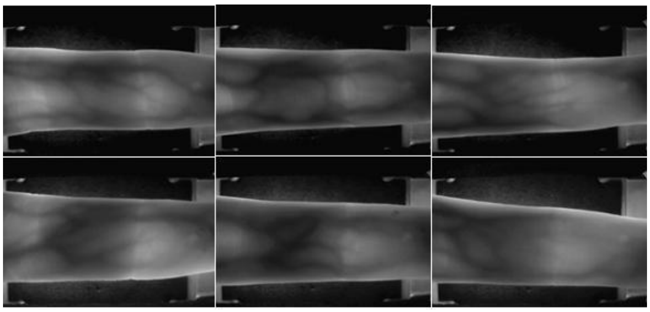

Fig 2. Sample images in the Database

## V. SYSTEM OVERVIEW

The system architecture segregate the entire system into four steps: data collection, pre processing, feature extraction and feature matching [5]. Generally, finger vein images are captured based on principles of light transmission or light reflection. Images are captured by passing near infra red light through fingers. Haemoglobin absorbs NIR light and hence the vein portions appear much darker than surrounding areas. Here images used are from an already available database.



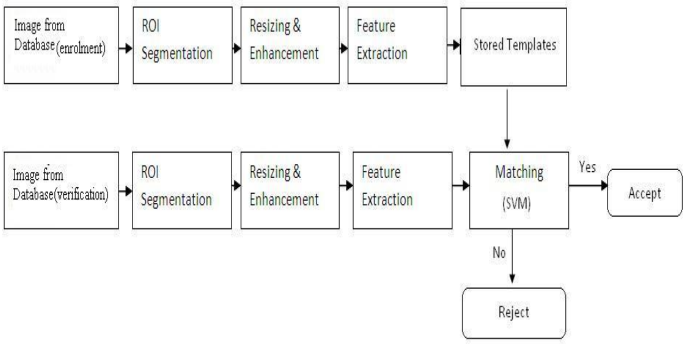


Fig 3. Algorithm flow chart

Various steps in detail are:

### *A. Image Segmentation and Alignment*

The entire region might not be needed for processing. So area of interest is to be selected and should be resized for future use. Also in case of different finger vein images position of fingers varies. So normalization of the images is done before feature extraction and matching. So a portion of finger vein image is segmented and is cropped out of the original image.

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Fig 4. Segmented ROI (Region of Interest)

### B. *Image Resizing & Enhancement*

The segmented image is initially resized to 1/4th of its original size .Then it is resized back to its original size. Next, the image is resized to 1/3rd of its original size.Bicubic Interpolation is used for this resizing procedure. Histogram Equalization is used for image enhancement. The histogram is a graphical representation of the information contained in the image. It shows how the intensity values of an image are distributed and the range of brightness from dark to bright. In this method contrast of the image is enhanced by increasing the dynamic range of intensity given to pixels with the most probable intensity value. One transformation function that accomplishes this is a cumulative distribution function.

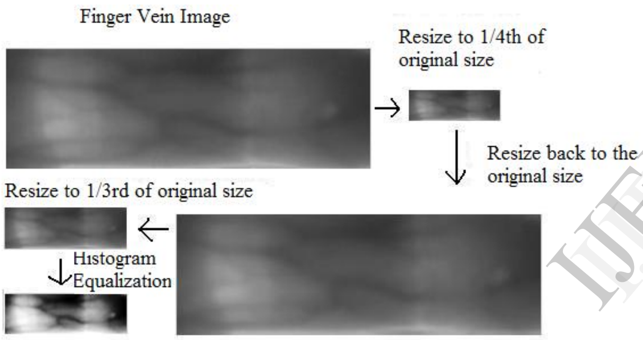


Fig 5. Resizing and Enhancement procedure

### C. *Feature Extraction*

The fractal model which was developed by Mandelbrot, emphasized the use of fractals as models for describing many rough phenomena in the world [6].Fractals are self-similar patterns .Here blanket method is used together with fractal model.A blanket surface is established on the images after pre processing [5].Various factors affecting the shrinking rate are also considered. Using the surface area value, the fractal dimension (D) of the image is measured.

$$u_e(i,j)=\max\{u_{e-1}(i,j)+1, \max_{|(m,n)-(i,j)|\le 1} \{u_{e-1}(m.n),u_{e-1}(i-2,j)\}\} \quad (1)$$

$$b_e(i,j)=\min\{b_{e-1}(i,j)-1, \min_{|(m,n)-(i,j)|\le 1} \{b_{e-1}(m.n),u_{e-1}(i-2,j)\}\}$$

The volume and surface area of these blanket surfaces are calculated.

$$V_e = \sum_{i,j} (u_e(i,j)-b_e(i,j)) \quad (2)$$

$$A_e= (V_e-V_{e-1})/2 \quad (3)$$

If e is very small, then,

$$A(e) =Fe^{2-D} \quad (4)$$

where F is a constant and D indicates fractal dimension (FD) of the image. By assuming two values for e we can obtain D by,

$$D=2- \{\log_2 a_{e1}-\log_2 a_{e2}/ \log_2 e_1-\log_2 e_{2\}} \quad (5)$$

Lacunarity is a measure of gaps in a n image. Higher will be lacunarity if the patterns are having more gaps. Images which are visually different may have similar fractal dimension .So it is difficult to distinguish among those images using D values. So lacunarity measurement is used. The image is obtained by,

$$d_e(i,j)=u_e(i,j)-b_e(i,j) \quad (6)$$

Let p(gy) be the probability of the intensity points whose gray values are gy on the surface of $d_e$.

$$M1= \sum_{i,j} d_e(i, j)\ p\ (d_e(i,j))$$

$$M2= \sum_{i,j} (\ p(d_e(i,j))\ d_e(i,j))^2) \quad (7)$$

The above equations give the first and second moments of this distribution.Finally, lacunarity can be calculated by,

$$\Lambda_e = (M2-(M1)^2)/ (M1)^2 \quad (8)$$

### D. *Feature Matching*

Here pattern matching is done by Support Vector Machines (SVM) [10].Support vector machines are supervised learning models .It is generally a binary (two-class) classification technique. They have associated learning algorithms to analyze data and recognize patterns. They are used for classification and regression analysis. It is based on the concept of structural risk minimization. It is so because it measures the maximum distance to the closest points of the training set. These vectors are termed as Support vectors. From the total images available, we use half of them for training and the remaining half for testing. The output value of SVM is used to check whether a genuine user or an imposter. A value close to 1 indicates a genuine user and a value closer to -1 indicates an imposter. Here 100 images were used for training and another 100 images were used for testing.

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## VI. RESULTS

The efficiency of SVM classifier is estimated by accuracy and precision measurement. This is done with the help of confusion matrix. A confusion matrix is also known as a contingency table or an error matrix. It is a table which allows visualization of the performance of an algorithm, mainly in case of a supervised learning one. In the matrix, each column represents instances of the predicted class and each row represents that of actual class. It has two rows and two columns that show the number of false positives, false negatives, true positives, and true negatives. False positive (FP) indicates the number of those instances that were actually negative were incorrectly recognized as true whereas true negative (TN) indicates correctly recognized negative instances .False negative (FN) indicates the number of instances that were recognized as negative although originally positive and true positive (TP) indicates those were correctly recognized as positive.

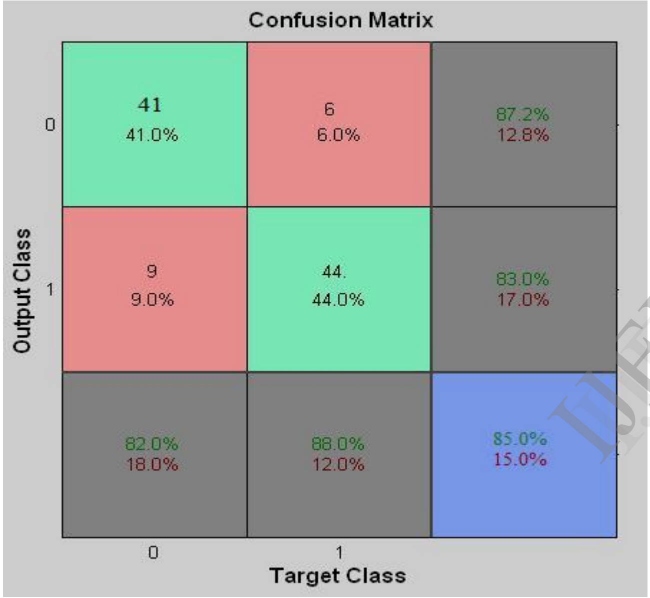


Fig 6. Confusion Matrix

The accuracy indicates the proportion of the total number of predictions that were correct.

$$\text{Accuracy}=\frac{TP+TN}{TP+TN+FN+FP}$$

The measured accuracy of this method is 85%.

$$\text{Precision}=\frac{TP}{TP+FP}$$

Precision of this method is obtained as 83.01%.

## VII. CONCLUSION

Finger Vein ID is a biometric authentication system that matches the vascular pattern in an individual's finger to previously obtained data There are some problems associated with existing system, namely, complexity in feature extraction, aligment problems etc.Alignment problems lead to rejection of authorized users. Here, in this system, after image acquisition, ROI (region of interest) is selected. Later that particular portion is cropped out and the remaining steps like image resizing, image enhancement and feature extraction are performed on that portion. Then pattern matching is done with the help of SVM (support vector machine).With the help of confusion matrix accuracy and precision values are calculated. The experimental results showed that accuracy of our method is 85% and precision is 83.01%.

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