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Vein Pattern for Personal Authentication

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Abstract **— It is essential to guard the secrete information from spoofing. Safe and sound personal recognition method is important in today’s e-world. This paper highlights the secure personal authentication using the finger vein pattern. The external biometrics traits tamper authentication system that affects the recognition accuracy. Vein pattern present beneath the skin is unique and not easy to spoof. This is the internal vein pattern which is safe and not affected from the wear, tear, and wet and dry condition like fingerprint. It is attractive technology that provides high security and reliability than other identification technology. This paper explores the finger-vein framework using the Kekre’s wavelet transform for global feature extraction. The algorithm is tested on the own finger vein database of 128x128 size of 500 samples of 50 users covers all category from teenager to senior citizen shows better recognition performance.**

Index Terms**—finger vein, finger vein sensor, Kekre wavelet transform, recognition.**

I. INTRODUCTION

Biometric is the current technology for personal authentication. Fingerprint is the popular for personal identification while face, iris, palm traits are used for the access control system in sensitive area [1-7]. Each trait has its own merits and demerits. The correlated modalities of hand are the fingerprint, finger knuckle and finger vein. Among these correlated biometric traits finger knuckle and finger vein is more protected. On the other hand all these technology have more chances in danger because the features used in the methods are exposed outside the human body. Hence less guarantee about the confidentiality that increases the chances of forgery. Finger veins are the internal pattern present beneath the skin where red blood cells are flowing. This pattern is captured by near infrared rays only 0.3-1.0 mm thick vein is visible [8].

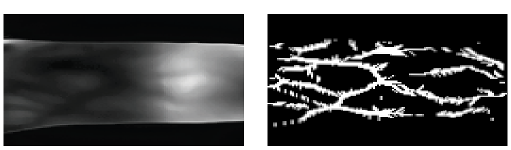

Fig.1 Finger vein pattern

Finger vein is safer because of its merits over the other biometrics are-

1. It is based on the contactless sensor and hidden under the skin and authenticate only alive person hence it is not easy to spoof and forge.
2. Highly secure and reliable for personal recognition, high accuracy hence easily acceptable by society.
3. Independent on the natural or artificial condition such as dry, wet, rough, soft, hard type etc. hence possible to cover large population during enrollment.
4. Vein pattern are unique for individual even for identical twins and not changes through the year. Table I shows the comparison of competent traits with finger vein.

TABLE I
COMPARISION OF BIOMETRICS TRAITS

Biometric Trait	Security		Feasibility		
	Anti spoofing	Accuracy	Collectability	Social Acceptability	Circumvention
Iris	Good	Excellent	Good	Average	Average
DNA fingerprint	Excellent	Excellent	Average	Average	Average
Finger knuckle	Good	Excellent	Good	Good	Excellent
Finger vein	Excellent	Excellent	Good	Excellent	Excellent

These vein patterns are acquired by NIR based capturing device. It is compact and not gets in touch with user. The vein pattern template is compact hence less memory space is required and authentication process is fast even for scalable database .That the reason this new technology is moving from researcher to commercial purpose for development.

II. RELATED THEORY

Many more researcher currently working on the finger vein capturing device as well as feature extraction algorithm some of the foundation work is highlighted.Zhongbo Zhang, Siliang Ma, Xiao Han designed the finger vein capture device and implemented a local interconnection neural network with linear receptive field to detect the straight-line feature i.e. vein pattern in small region [9]. Naoto Miura and et .al. worked with unclear images and extract the vein pattern using special line tracking algorithm. That algorithm shows good performance as EER is 0.145%. The vein patterns were extracted using gradient normalization, principal curvature calculation, and binarization. Experiment demonstrated better improvement as compare to conventional methods [10].
Extraction of geometrical parameter obtain the minimum and maximum value between two lines of cross section of vein pattern and matching is done using the Hausdorff, Fat, maximum minimum distances. Support vector machine (SVM) classifier support to score level fusion [11].Feature extraction using phase only correlation shows EER is 0.98%[12].

III. FINGER VEIN CAPTURING DEVICE

The finger vein capturing device is based on the NIR LEDs and IR sensitive camera. Vein patterns are hidden to normal

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eye, can be seen through near infrared sensor of wavelength 700nm-1000nm [15][16].

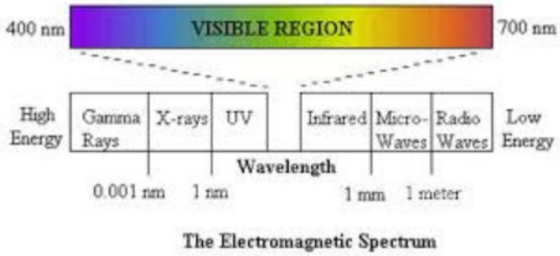

Fig.2 Electromagnetic spectrum [28]

There are different types of IR sensor to capture the finger vein pattern as shown in Table II. [21][25-26]

TABLE II
FINGER VEIN READERS

Finger vein Reader	Sony	Hitachi	mofiria-FVA U2SXA	Proposed
Framework				
Dimensions	Smaller than 1ml	59 (W) x 82 (D) x 74 (H) mm	70 *22.5 *58mm (W/H/D)	800(W)x65(D)x150(H) cm
Weight	Not mentioned	96g	Approx. 36 g	75g
Power supply	Not mentioned	Not mentioned	USB Bus power	USB Bus power
interface	Not mentioned	USB 2.0	USB2.0 Full Speed	USB 2.0 backward compatible with USB 1.1
Capture System	Low-cost CMOS device	Infrared LED + Camera	CMOS sensor	IR camera-Webcam (i Ball face2fcae 8.0)
Environmental condition Ambient Temperature Humidity	Possible to verify under the Sun Light	5 – 35 deg. C 20 – 80% (No Condensation)	20%~80% (No condensing)	Possible to verify under normal, cold condition

A. *Proposed finger vein reader*

Proposed finger vein reader is designed as per the practical aspect such as compact , contactless , easy to capture, low cost , and can form own database as per the requirement .
1. IR camera that captured vein pattern supports all hardware and software unit of recognition.
2. Entire unit should support the external display such as desktop, laptop, LCD etc.
3. It can be easily moveable anywhere.
4. Based on NIR imaging so non-contact.

Table II shows the all above aspect that meet the design objectives. Only the size of proposed device is not as compact to commercial reader .It is designed as per the distance between the camera and finger that gives better illumination and clarity about the vein pattern [14].

The proposed finger vein device is medium in size and weight. Simple webcam is used as IR sensor by removing the IR filter so cost of capture system is less as compare to others [27]. The size of the vein pattern is 128x128 after pre processing the raw sample so template size is not too large that gives less computer complexity and fast processing speed. The fig 3 shows the actual physical set up of vein pattern capturing.

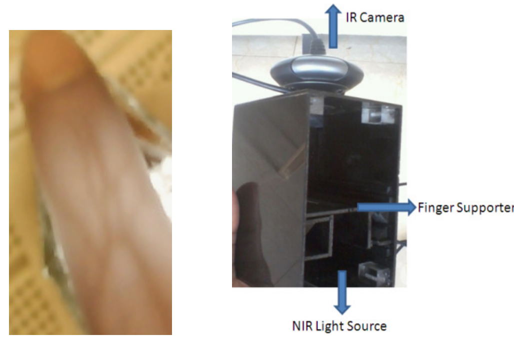

Fig.3 Physical set up of finger vein acquisition

User can place tip of finger on non contact finger supporter notch. It is designed in such a way that any finger can place easily without reservation of thickness and alignment. NIR light passes through the finger that captured by the IR camera placed at top and transfer vein pattern to external display.

B. *Own finger vein database*

Finger vein database is formed from the educational organization. Database of 50 users including VIP to fourth class peoples are included. Own finger vein database is ready with the attributes for primary and soft recognition purpose as shown in fig.4.Primary attributes recognize the unique or hard characteristics of vein pattern while soft will enhance the primary biometric recognition using non unique characteristics. Total database of 500 samples are collected by the proposed vein capturing device.

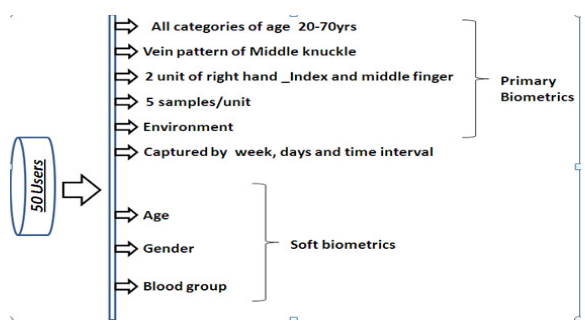

Fig.4 Finger vein database

IV. FINGER VEIN RECOGNITION

Raw image of finger starts from nail tip to end of third knuckle. Region of interest is vein pattern present between the upper and middle knuckle. ROI is cropped and undergo the de

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noising by bilateral filter [17][18]. De noised sample is enhanced by the contrast limited adaptive histogram equalization [19][20]. The finger vein recognition flow is as shown in fig.5. Total database of 500 vein patterns of 50 users are considered. Each user gives 10 samples among them the 3 samples used for testing i.e. verification that follows 1:1 matching while remaining 7 samples used for training i.e. identification that follows 1: N matching.

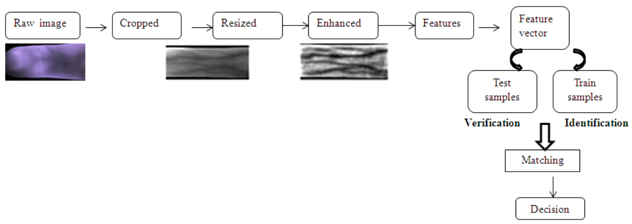

Fig.5. Flow of finger vein recognition

A. *Feature vector*

In proposed recognition system the features are extracted using the Kekre wavelet transform. Global level features are extracted using the wavelet transform. These features are unique features that verify the identity of claim person. Soft features will consider in the next phase which is the non unique features that enhance the accuracy of unique features

B. *Wavelet*

Wavelet is useful to provide the information of given signal or image in time as well as frequency domain. Basically it is a mathematical function when applied on image it divides the data into different frequencies. It is the tool that applied for data processing, compression. In the proposed system the wavelet is used for feature extraction of the vein pattern.
Wavelet is advantageous over Fourier transform because it has frequency resolution and time resolution. Fourier has only frequency resolution but it is not affected stationary signal. Fourier transform is not suitable for non stationary signal as it is not able to show exact frequency and exact time of occurrence of this frequency in a signal. Wavelet is solution to overcome the demerits of Fourier transform by providing the variable size windowpane method. Each window gives information at different frequency. For new interval same process can reaped to extract more number of features. Wavelet is time scale representation. It is capable of exposing feature of data such as discontinuities, breaking points, higher derivatives that other signal analyses ignore these features. Wavelet is classified into two: i) Continuous wavelet Transform (CWT) and discrete wavelet transform (DWT). CWT is difficult to use because of their properties such as i) redundancy of the CWT. ii) Without redundancy still infinite number of wavelet in the wavelet transform.iii) For most functions Wavelet transform have no analytical solution and can be calculated numerically by a computer. The different wavelet families as

- Haar- discontinuous and resembles a step function.
- Daubechies-compactly supported orthonormal wavelet (dbN) where N is order
- Mexican Hat- has no function. Derived from the function that is directly proportional to second derivative function of the Gaussian PDF
- Meyer –the wavelet and scaling function are defined in frequency domain
- Kekre-it is a current approach to create new wavelet. Propose algorithm to generate DWT from any orthogonal transform.

Wavelet is function generated from a single function by dilation and translation. This set of functions must be orthogonal. But only few functions satisfy this condition of orthogonality. Kekre proposed a generalized algorithm to generate DWT from any orthogonal transform; wavelet functions satisfy the all properties of wavelet [22]

C. *Kekre Wavelet*

Kekre wavelet is selected for feature extraction of vein pattern because the Kekre's wavelets are orthogonal family of wavelets.Kekre's transform matrix can be of any size NxN, which need not to be an integer power of 2. All upper diagonal and diagonal elements of Kekre's transform matrix are 1, while the lower diagonal part except the elements just below diagonal is zero [23]. The general Kekre's matrix [K] is given as

$$K_{NxN} = \begin{bmatrix} 1 & 1 & 1 & \dots & 1 & 1 \\ -N+1 & 1 & 1 & \dots & 1 & 1 \\ 0 & -N+2 & 1 & \dots & 1 & 1 \\ . & . & . & \dots & . & . \\ . & . & . & & . & . \\ . & . & . & & . & . \\ 0 & 0 & 0 & \dots & 1 & 1 \\ 0 & 0 & 0 & \dots & -N+(N-1) & 1 \end{bmatrix}$$

The formula for generating the element Kxy of Kekre's transform matrix is,

$$Kxy = \begin{cases} 1 & ; x \le y \\ -N + (x-1) & ; x = y + 1 \\ 0 & ; x > y + 1 \end{cases} \quad \dots [1]$$

1. Kekre's Wavelet transform (KWT) is derived from Kekre's Transforms matrix (KTM)
2. Design MxM Kekre's Wavelet transform from N x N Kekre's transform matrix.
3. KWT of M designed in such that M = N * P where P is integer between $2 \le P \le N$
4. Repeate every column P times gives first N number of rows of KWT.
5. To generate remaining rows, generate temporary matrix T. last (P-1) rows and last P columns from KTM store in T.

Features like energy coefficients are obtained from the low frequency and high frequency component .More number of iteration gives more energy coefficient which is used for further matching unit. Stored and claim vein pattern is matched using Euclidean distance [24].The flow of feature extraction as shown in fig.6.

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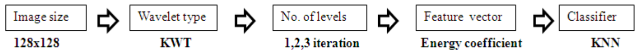

Fig.6 Flow of features extraction

Image size of 128x128 divided into 3 parts left, centre and right. Applies the designed KWT on each part as shown in fig. 7

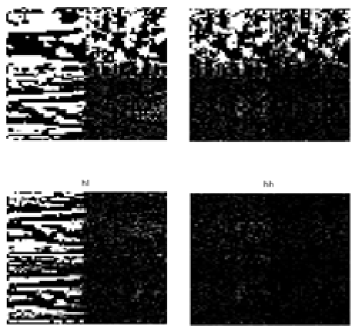

Fig.7 Transformed finger vein pattern(a) Low Low(b)Low High(c)High High(d) High Low

Transformed image shows the information of vein at different frequencies. These 4 blocks are LL, LH, HH and HL that shows texture information in row, column and diagonal wise. Most of the important information is present in the LL part so extract that part and repeat procedure for l 3 iteration to get more number of features. 36 features obtained in each iteration such 3 level gives 108 features i.e. energy coefficient. Extracted features are saved in mat file that required matching stored vein pattern to claim vein pattern. Both the vein template matched using Euclidean distance [24].

V. Result and Discussion

Proposed KWT is tested on the testing database of 150 testing and 350 training database of finger vein images. Testing finger vein samples are used for verification i.e. 1:1 matching means sample of user is matched with another samples of same user. Training finger vein samples are used for identification i.e. 1: N matching means sample of user is matched with N user present in the database. Calculated Euclidean distances between test and train are the threshold for the authentication.

TAR versus TRR graph shows calculated threshold on X-axis and the recognition accuracy in percentage at Y- axis.

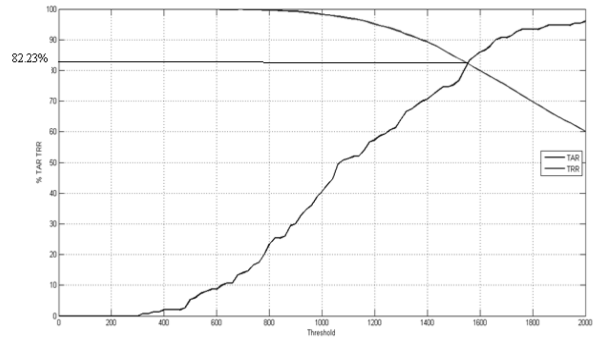

Table III shows the recognition result of KWT on finger vein.

TABLE III
FINGER VEIN RECOGNITION ACCURACY USING KWT

Sr.No.	Method	TAR vs. TRR	FAR vs. FRR
1.	KWT tested on readymade database	86.3%	13.7%
2.	KWT tested on readymade database	82.23%	17.7%

VI. Conclusion

The proposed algorithm is tested on the enhanced and raw finger vein database but recognition result on enhanced finger vein is better than raw finger vein database as shown in Table III.The recognition accuracy of the own database is 4 % less than the readymade database[29]. KWT is enabling to extract the finger vein features for the authentication but the recognition accuracy is less as compare to the finger knuckle modality using KWT [24]. In next phase in order to get better accuracy of finger vein recognition the hybrid wavelet will be proposed for feature extraction.

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