SIFT based Dorsal Vein Recognition System for Cashless Treatment through Medical Insurance

Rajendra Kumar, Ram Chandra Singh, Ashok Kumar Sahoo

Abstract: The time has come not to carry any physical personal identity. The person's identity will be known by his/her biometric features for any purpose exclusively when the person is unconscious and not carrying any identity proof. Vein recognition system is leading biometric trait in terms of flexibility and security. The fake recognition of veins is almost impossible as the feature points lie underneath the skin and cannot be read without the knowledge of a person (if not unconscious). Most important thing about it is that vein recognitionsystem works only in living persons. In this paper, a recognition system is proposed that works on dorsal vein to claim cashless treatment in a hospital which is on panel of medical insurance company. For acquisition of vein image, a NIR camera VF620 of 850 nm wavelength is used. The proposed model is applied on 1000 samples of dorsal vein patterns of 250 persons. The overall performance of the system was observed to be 97.95% with EER (Equal Error Rate)0.0435%.

Index Terms*: *Veins Pattern Recognition, Biometric Identification, Dorsal Vein Biometric, SIFT, Pattern Recognition.

I. INTRODUCTION

For every identification, security and convenience are the prime objectives. If the identity features in a biometric identification are inside the body and cannot be extracted without the consent of a person then it becomes more secure. Vein pattern recognition and identification give such kind of flexibility [1]. It has already been proved that vein patterns are unique even in twins [2] and therefore difficult to forge. Additionally, it has no effect in matching whether there is case of skin discoloration, light conditions, minor distance variation from camera to dorsal, etc. [3]. The contactless feature makes it more better than fingerprint recognition.

Several challenges have been observed in different biometric recognitions, like scaling segmentation, quality and other physical conditions in latent fingerprints; Quality of scanner, co-operation by user with recognition system, etc. To overcome the problem of scaling, the SIFT (scale invariantfeature transform) algorithm have shown very good results.

The identification of a person was started with ICard, Password, PIN, etc. But these were not reliable with time as these can be stolen, unknowingly disclosed and forgot. A K Jain et al.**[4]**have shown that as the technology progressed, the physical characteristics/biological features (like fingerprint, palm print, iris, face, etc.) came into effect and commercially applied for authentication. With the time it is notices that the unauthorized duplication of fingerprint and palm prints spoofed the authentication system [4] came in knowledge.To avoid the unauthorized duplication of fingerprints and palm prints, it is highly desirable to use the person's biological features that cannot be reproduced without the consent of the person [5]. This led the researchers to use veins pattern (palm, finger, etc.) as one of the biometric traits [6]. Bango Chao Liu et al. used LBP (Local Binary Pattern) for vein recognition [6]. Sen Lin et al. focused on finding ROI (region of interest) to get better feature point extraction for high matching [7]. To improve the security,Parthsarthiet.al. [8] used dual authentication and Jaekwon Lee et al. [9] used liveliness of the user to detect spoofing. Montiel et.al.used segmentation for better recognition [2].

Several biometric traits have been developed so far like fingerprint, iris, face, etc. [10]. Maleika et al. used palm vein patterns as biometric recognition as it has more area to have sufficient feature points [11]. Every trait has its advantages and disadvantages and based on that they are implemented commercially. In India, fingerprints are being used in AADHAR card [12]. Iris is being used at airports. In recent years many cases of fingerprint imitations have been reported and therefore it cannot be treated as a most secure biometric trait. A person's fake fingerprint can be misused for different purposes. The fake vein patterns cannot be developed by any means as it is captured by NIR camera and person's physical appearance is must for same.

Hardika et al. proposed multi-feature fusion finger vein recognition using SIFT and LEBP (local extensive binary pattern). This method overcame the problem of image degradation due to image operations like scaling, rotation and translation. It has been observed that variation in illumination creates problem in feature extraction by SIFT[13]. To overcome this problem Wang et al. [14]used LEBP as it hasfeature to resist variation in illumination conditions. They also proposed SIFT based vein recognition model focusing on contrast enhancement (CE).

Hans Verghese Mathews et al. presented flaws in the UIDAI Process by mentioning major challenge in unauthorized uses [15].Naidile et al. [16] proposed a dorsal hand vein recognition system. Simple correlation technique was used by them for matching purpose. The system presented in [16] produced positive detection rate of 75% and negative detection rate was 25%.

Wang et al.[14]discussed that scale-invariant feature transform (SIFT) is being investigated more and more to realize a less-constrained hand vein recognition system. Contrast enhancement (CE), compensating for deficient dynamic range aspects, is a must for SIFT based framework to improve the performance.

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However, evidence of negative influence on SIFT matching brought by CE is analyzed by their experiments [17]. Sen Lin et al. [18] focused on methods of extracting region of interest (ROI) for palm vein recognition

Mulyono et al.[19] used finger vein grabber device SMT780 (Marubeni Corporation's product) with wavelength 780 nm for image capturing. Raghvendra et al. [12]used a sensor based on a near infrared illumination that can emit light in a spectrum of 940 nm that in turn is used to illuminate the dorsal hand region.Kumar et al. [20] applied triangulation and shape feature on personal database of dorsal vein patterns to produce EER 1.14%. Antonio et al. [21]used minutiae extraction algorithm on Singapore database of dorsal vein patterns to produce EER 1.63%. Yuksel et al. [22] used geometric and appearance based fusion on Bosphorus database and produced EER 1.98%.

The motivation behind this study is that the vein patterns are unique even in twins. This technology works only on live persons as hemoglobin in veins absorbs the infrared light and the veins appear black to be captured for identity. Since,vein patterns are underneath the skin therefore capturing of vein pattern is difficult without consent of user. Its contactless feature makes it durable and hygienic. Last but not the least its commercialization is very limited.

The paper is organized as follows.Section II presents the model of the proposed system. The implementation of the proposed system is discussed in Section III. Section IV presents the results and Discussion and finally, section V concludes the outcome of this work along with the future scope.

II. THE PROPOSED MODEL

The proposed system is aimed to provide the cashless treatment facility in the hospitals which are on panel of insurance company. The system contains three major sections: insurance company, hospital and policy holder.

Insurance company – The insurance company insures a customer by taking documentdetails like name, date of birth, phone number, address, family details and captures dorsal vein pattern (by NIR Camera) of left and right side for identification. The medical insurance company issues insurance policy to customer that contains all the details of customer and the risk covers along with the list of hospital on its panel.

Hospital – The hospitalmaintains list of insurance companies to which hospitals are associated. When a new medical insurance is issued to a customer, the details of customer along with the vein patterns (in encrypted form) is accessed by the hospital from insurance company server. Some such systems are already in use, but in different way like, Bethanny et al. [23] used finger vein data of all patients to keep their record for further biometric identification.

Policy Holder – There are two ways in which a policy holder can be treated: (i) Planned cashless treatment (as some disease is diagnosed) and (ii) Causality (as insurance policy holder meets with some causality).

In planned cashless treatment, the insured user contacts to hospital for treatment of decease as diagnosed. The hospital scans the dorsal veins of patient by NIR camera attached to the system. The system instantly identifies the customer and shows the details of patient and fixes an appointment for treatment. The details of patient, treatment duration, treatment cost and other status are updated at insurance company server. The DFD (data flow diagram) in Figure 1 shows how this system associates a policy holder (insured user) with insurance company and hospitals on its panel.

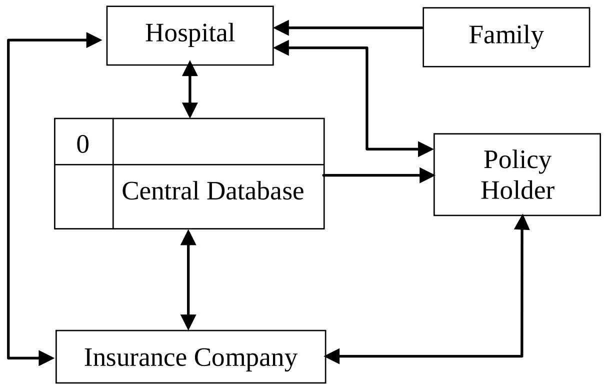


Fig. 1. 0-level DFD of the system

In case of causalities, if an unconscious person is found without any ID, is supposed to be taken to hospital. May be person met with some crime and person's ids were destroyed or stolen and the person is in unconscious condition. This case is represented by data flow diagram shown in Figure 2.

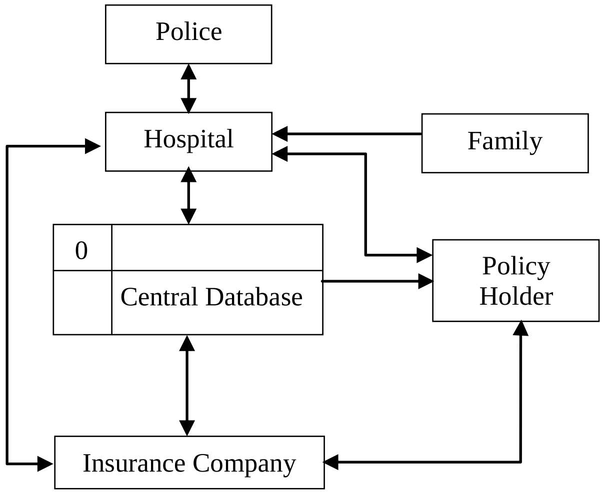


Fig. 2. 0-level DFD of the system

The person under causality is supposed to be sent to nearest hospital by someone. The hospital person scans the patient's dorsal and system tells: whether the person is under medical insurance; what risks are covered and upto what amount; person is eligible to which hospitals for cashless treatment. The system sends update on every scan of dorsal vein to the insurance company for security purpose so that no hospital able to do any fraud. Instantly, all the details of the person will be displayed on the system if he/she is medically insured already. If the hospital is not on panel of insurance company from which the person is insured then the person will be sent to nearest hospital on panel for treatment and the family of that person will be informed by the system through automatic email and SMS. If no record of patient is found, then person will be referred to government hospital and case will be informed to police for further action.

Figure 3 shows the flow chart representation of Figure 2.

When the unconscious person is taken into hospital, the hospital first identifies the person's identity based on dorsal vein pattern with the central database of dorsal vein patterns of insured persons. If the person is medically insured then cashless treatment will be started and simultaneously the system will send message/email alerts to insurance company, insurance agent and person's family. If the person is not identified then hospital will inform to police for identification and treatment.

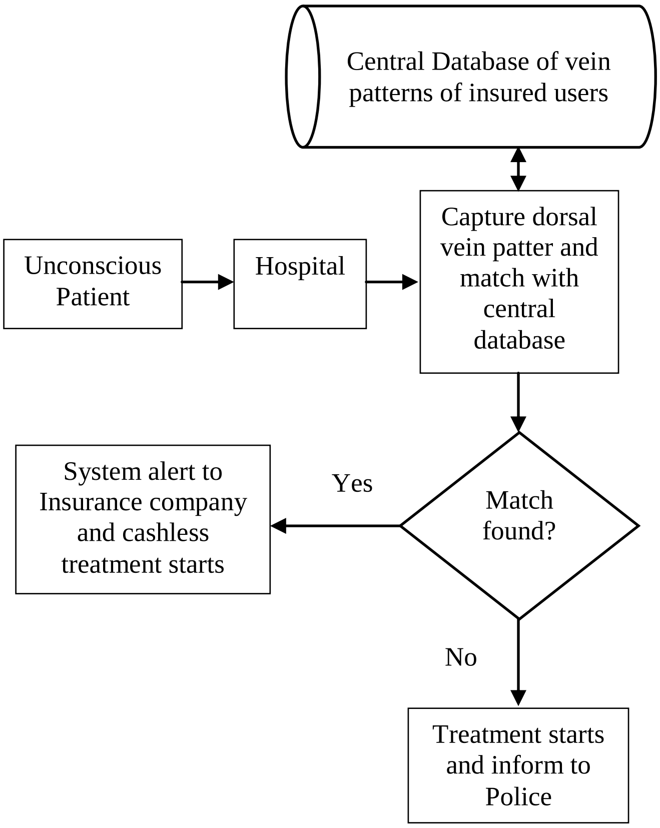


Fig. 3. Verification of unconscious patient in Hospital

Based on details and capturing of dorsal vein pattern of insured person, the central database is updated. Now the policy holder (insured person) can create his/her account to know the details of insurance and claim when required. The hospital modules can access the updated records as per insertion/deletion of records in central database. The record of a user is disabled if the insurance is not renewed within the deadline. Such users can be identified but they are not entitled for cashless treatment.

Policy Holder– As a new person is insured by an insurance company, his/her details are added to the system. Same updated details will now be accessible to hospitals. The insured person creates his/her account in the system by entering the policy number and registered mobile number/email shared with the insurance company. The system sends an OTP (one-time password) to registered mobile number/email. After entering the OTP, the system displays all the information of user which are shared with the insurance company. Now the user will be asked to enter desired password for future access. The policy number is used as the default user identity. The flow chart account creation at user end and hospital end (newly established) is shown in Figure 4.

Hospital- If a new hospital is open and wish to associate with some insurance companies,the hospital can create an account in the system. After physical verification, the hospital is assigned a hospital code and shared with policy holder through updated system.

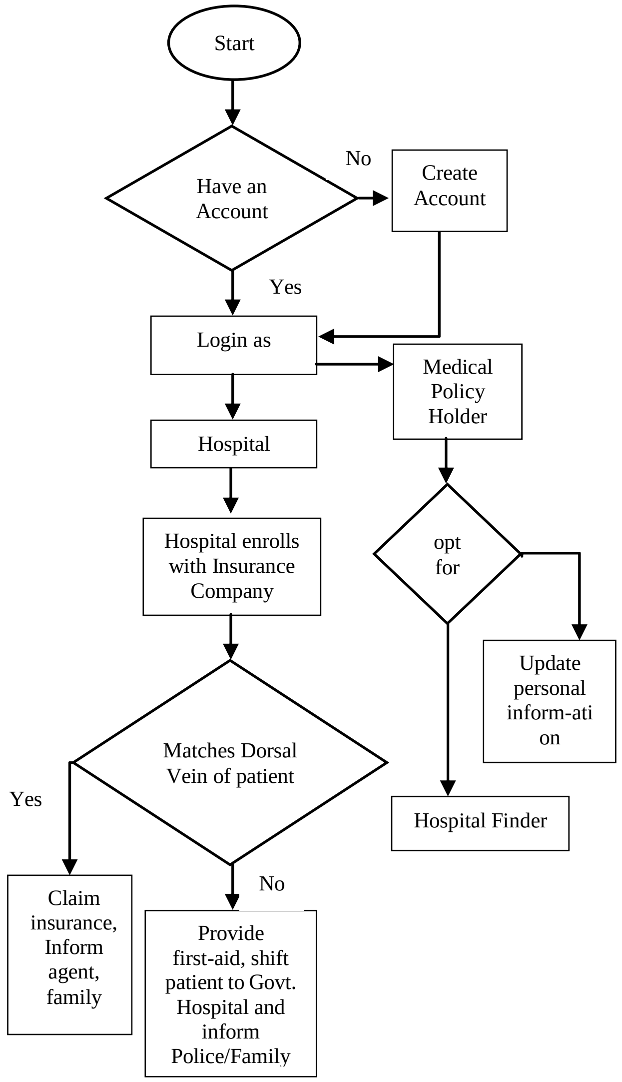


Fig. 4. Flow chart for user/hospital account creation

The data flow diagram of the entire system is presented in Figure 5, below.

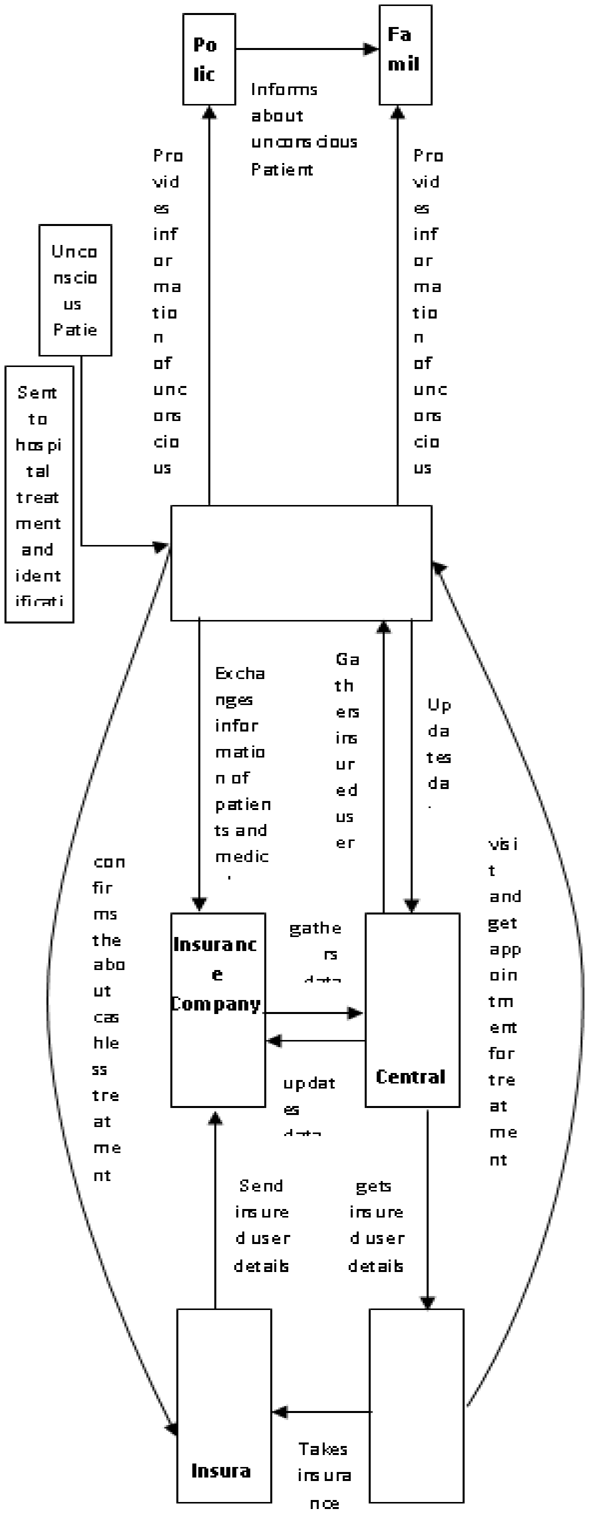


Fig. 5. DFD of the proposed system

III. IMPLEMENTATION

A. Software Specification

Python 3.7.3 with OpenCv package is used as software support on Win 10 platform.

B. Hardware Specification

The system needs around 5 Mb space for storage of program code and 215 KB for four images (2 images of left dorsal and 2 images of right dorsal) per person. The system executed on Intel(R) Core™ i5-7200U CPU with 2.5 GHz and 8GB RAM.

C. Data Acquisition

The hardware used for capturing the vein patterns is NIR camera (VF620) of wavelength lying between 700 to 1000 nm. When infrared rays of this range passes through human tissues, the hemoglobin in blood absorbs the infrared radiation. As a result, the vein patterns can easily be captured.It is contactless function giving the helpful advantage (hygienic) over fingerprint and palm print [24, 25].

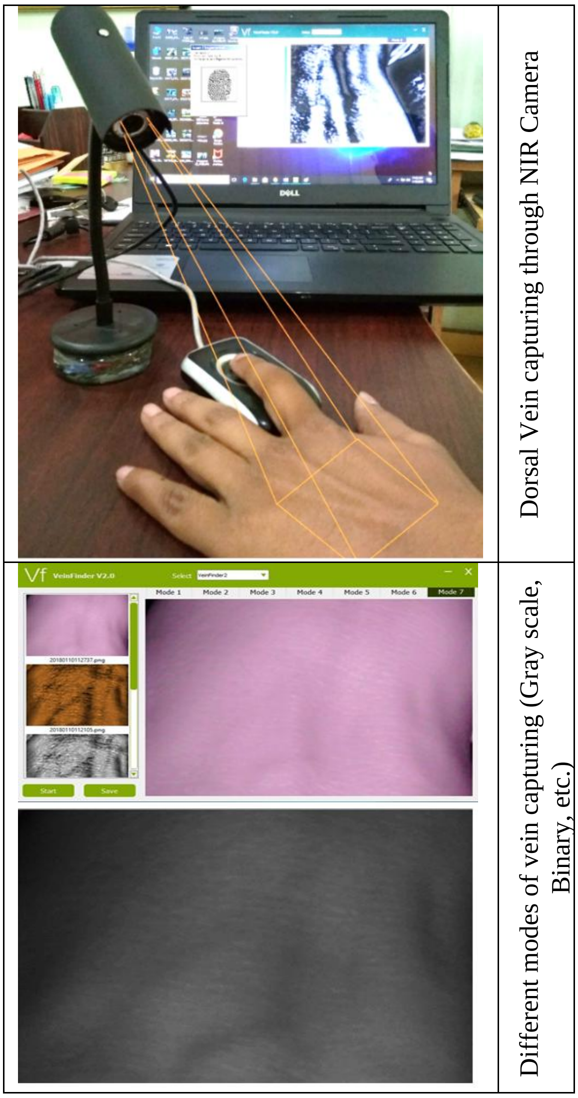


Fig. 6. Vein pattern capturing during enrollment

A near infrared camera (NIR) is used to capture the veins pattern. When the finger/palm is illuminated with infrared radiation, the veins appear black and same are recorded as identity attributes in a biometric system and further can be used for comparison during authentication [26]-[28]. The process of data acquisition involves use of appropriate software and hardware.

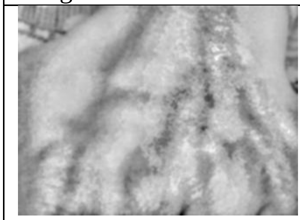
D. Image Specification

Images of size 320×240 in .png format are used in experiments. The dorsal vein patterns of 250 persons including 80 male adults, 80 female adults and 90 kids of age 05 years to 12 years are captured.

E. Object Collection

The dorsal vein captured during enrollment is shown in Figure 6. Sample images of male adults, female adults and kids are used in the experiments. Vein pattern sample of male user is given in Figure 7. The information like name, date of birth, contact number, address and date of capturing.

Name: Nitin Garg
Gender: Male
Age: 40
Contact No.: 8630047453
Address: 150, Sabun Godam Mandi, Meerut
Image taken on: 16 Oct. 2018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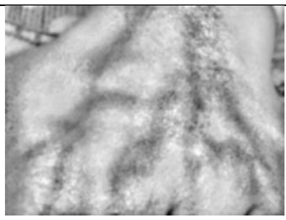
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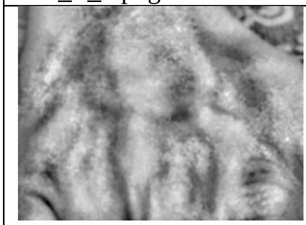
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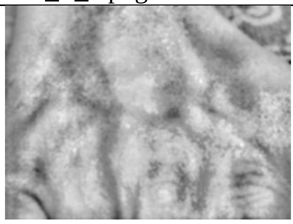
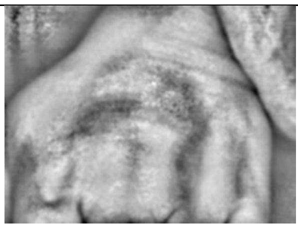

040_R_2.png

Fig. 7. Dorsal vein samples of a male adult

Vein pattern Sample of Female user is given in figure 8.

Name: Sunita Verma
Gender: Female
Age: 50
Contact No.: 9927002695
Address: 165, Sabun Godam, Meerut
Image taken on: 16 Oct. 2018


045_L_1.png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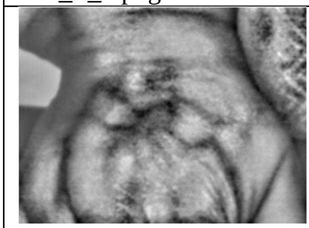

045_R_1.png

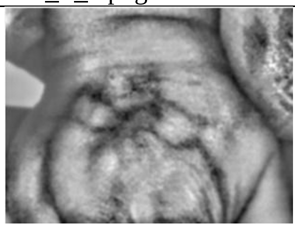
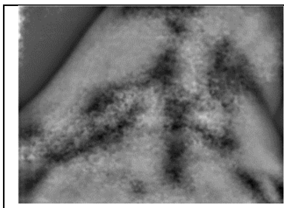
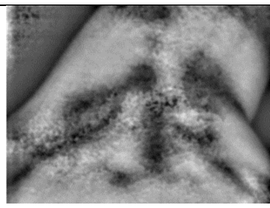

045_R_2.png

Fig. 8. Dorsal vein samples of a female adult

Vein pattern Sample of kid user is given in Figure 9.

Child Name: Disha Aggarwal
Age: 9 yrs.
Gender: Female
Father Name: Mr. Pukar Aggarwal
Contact Number: 8958913120
Address: 168, Sabun Godam, Meerut
Image taken on: 16 Oct. 2018


007_L_1.png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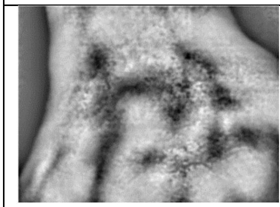
007_R_1.png


007_R_2.png

Fig. 9. Dorsal vein samples of a kid

F. Persons' Identification

Dorsal Vein Pattern Capturing - This module captures the dorsal vein patterns of a user with NIR camera attached with the system sharing the central database of insured persons.

Finding ROI - This determine the region of interest (in block of 320×240) where maximum feature points are available for better matching.

Image Enhancement - To eliminate the dark region of the input image, a morphological operation is used as

$$\emptyset_f^{(sB)} = max\{min\big(f(x+b)\big)\}$$

where, *sB* represents structuring element *B* of size *s*, *f* is input image and $b \in sB$.

Morphological operation is done to obtain dark vein patterns on which contrast enhancement is applied. The contrast enhancement is done using *A*×*A* window. Mathematically, the contrast enhancement (output image *G*) is done by

$$G = 255\frac{[\propto_A(\emptyset_f) - \propto_A(\emptyset_{f_{min}})]}{[\propto_A(\emptyset_{max}) - \propto_A(\emptyset_{f_{min}})]},$$

$$\propto_A(\emptyset_f) = [1 + \exp\left(\frac{m_A - \emptyset_f}{\sigma_A}\right)]^{-1}.$$

$\emptyset_{fmin}$ and $\emptyset_{fmax}$ represent the minimum and maximum intensities, m_A and σ_A represent the mean and variance inside the window area.

Object Identification with Central Database - For identification of an unconscious patient, the hospital personnelscan the dorsal of left and/or right hand. The scanner is connected with central database of vein patterns of insured users from different insurance companies. NIR Camera of 850 nm is used for capturing dorsal vein images. For dorsal vein identification at hospital end, SIFT feature matching algorithm is used. The process of verification of unconscious patient (having no physical identity) is shown in figure 10.

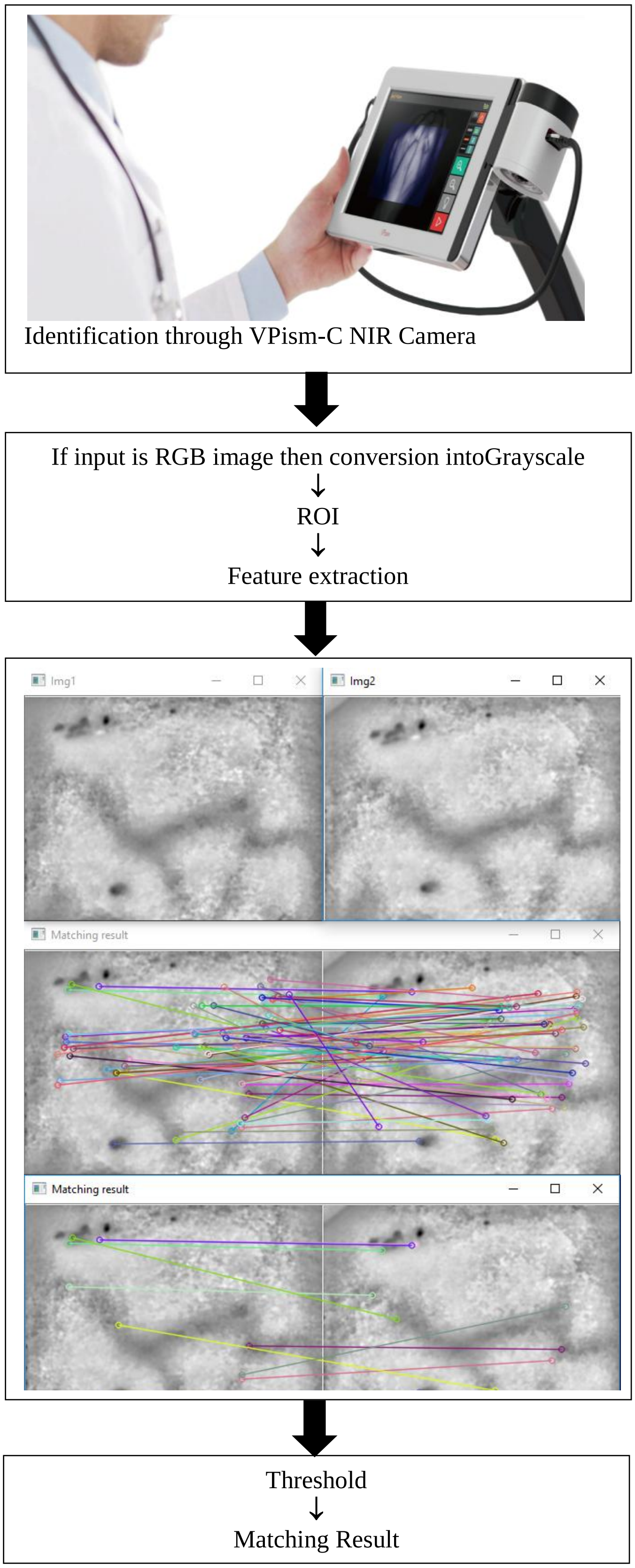

Fig. 10. Identification of patient for cashless treatment

Python 3.7.3 with OpenCv package is used as software tool. After image capturing by dedicated scanner(s), the remaining operations (pre- and post-processing) are ensured by the software tool. The pre-processing of image includes image enhancement and noise removal; while the post-processing of image includes feature extraction, matching and result analysis.

IV. RESULTS AND DISCUSSION

For experimental purpose, the data of 250 persons was considered. Total 4 images of a person (2 images of left hand L1, L2) and 2 images of right hand R1, R2) were captured after an interval of 30 minutes. Total images we used for this research work were 1000 and total matching come out from 10,00000 comparisons. We had total imposters score (male, female and kids)= 980000 results, and total genuine score (male, female and kids) = 20000. The FAR (false accept rate) was calculated as:

$$FAR = \frac{\text{Number of samples false accepted at a threshold}}{\text{Total number of attempts}}$$

Table-I. FAR of full data Imposter scores

S. No.	Threshold %	FAR
1	40	0.0794
2	50	0.0277
3	60	0.0092
4	70	0.0021
5	80	0.00
6	90	0.00

The FRR (false reject rate) was calculated as:

$$FRR = \frac{\text{Number of true rejected at a threshold}}{\text{Total number of attempts}}$$

Table-II. Total genuine score

S. No.	Threshold %	FRR
1	40	0.040
2	50	0.045
3	60	0.049
4	70	0.080
5	80	0.115
6	90	0.220

The overall performance of the proposed system calculated on total imposter results = 979500 with FAR at threshold 40% = 0.0793. Almost similar performance was found on threshold more than 40%. The overall performance P is calculated as

$$P = \frac{(Total\ imposter\ results - FAR)}{Total\ results}$$

= (979500 - 0.0794)×100/1000000
= 97.95%

The performance of the system at threshold 50%, 60%, 70%, 80% was found 97.99% and at threshold 90% it was found 98%. Therefore, the average performance of the system was 97.99%.

The plot of FAR and FRR from Table I and II is shown in figure 11 to calculate EER. The EER of the system obtained was 0.0435% which is better than results obtained in [20] - [22].

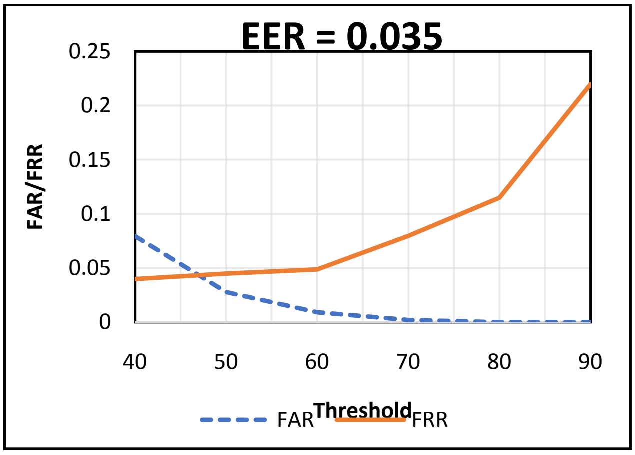

Fig. 11. Determining EER from FAR and FRR graph

For category based matching, we have divided matching into three parts:

(i) Male, female and kids matching scores with their left and right images,

(ii) Male, female and kids matching scores matched with the same group, and

(iii) Male, female and kids matching scores matched with all samples.

With reference to (i), we obtained male, female and kids matching scores with their left and right hand dorsal vein images as - total number of genuine score for male = 3200 (for left), total number of genuine score for male = 3200 (for right), total number of genuine score for female = 3200 (for left), total number of genuine score for female = 3200 (for right), Total number of genuine score for kids = 3600 (for left), and Total number of genuine score for kids = 3600 (for right).

Table-III Category wise FRR

Threshold %	Male Dorsal		Female Dorsal		Kids Dorsal	
	Left (3200)	Right (3200)	Left (3200)	Right (3200)	Left (3600)	Right (3600)
40	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
60	0.0000	0.0000	0.09375	0.03125	0.0000	0.0280
70	0.0000	0.0000	0.09375	0.03125	0.0000	0.0280
80	0.0000	0.0000	0.1875	0.1250	0.0280	0.0830
90	0.0625	0.0000	0.2500	0.21875	0.0550	0.0555

As (ii), we obtained Male, female and kids matching scores (excluding genuine results) matched with the same group as - total number of imposter score for kids = 122400, total number of imposter score for male = 96000, and total number of imposter score for female = 96000.

Table-IV Category wise FAR in same group

Threshold %	Male Dorsal 96000 Samples	Female Dorsal 96000 Samples	Kids Dorsal 122400 Samples
30	0.0114	0.4270	0.1300
40	0.0000	0.0250	0.0370
50	0.0000	0.0042	0.0155
60	0.0000	0.0021	0.0024
70	0.0000	0.0000	0.0000
80	0.0000	0.0000	0.0000
90	0.0000	0.0000	0.0000

As (iii). We obtained Male, female and kids matching scores (excluding genuine results) matched with all samples of dorsal vein patterns as -total number of imposter score for kids = 352800, total number of imposter score for male adults = 313600, and total number of imposter score for female adults = 313600.

Table-V FAR for Males, Females and Kids (all samples)

% Threshold	Matching of Male (313600) to all Samples	Matching of Feale (313600) to all Samples	Kids to all 352800 Samples
30	0.055	0.041	0.091
40	0.016	0.014	0.027
50	0.001	0.002	0.001
60	0.001	0.000	0.001
70	0.000	0.000	0.000
80	0.000	0.000	0.000
90	0.000	0.000	0.000

V. CONCLUSION

The accuracy of the proposed system isfound to be 97.95%. The system rejected all imposter matching at 70% and above threshold as mentioned in tables IV and V. This system is capable to help in hassle free claim of medical insurance. Also, the system will identity if there is any fake claim. The results may vary due to acquisition of input image from different NIR cameras. After an interval of 05 and 10 years the vein patterns should be updated for kids and adults respectively. As this work does not include how much the vein patterns of kids may vary in 2-3 years, so as future scope this work may be done. Also, the future work needs to include database of vein patterns of persons having skin diseases and hypertension.

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