Dorsal Hand Veins Based Biometric Recognition System Using Hybrid Processing Algorithms

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Abstract : The desire of economy, reliable and alternate to contact based biometric systems led to invention of many Biometric recognition options. Among the most operated options are fingerprint recognition, iris recognition, face recognition, voice recognition, etc. However, based on convenience and performance of these standard methods have some issues. Every human hand has specific vein patterns. Dorsal hand veins based recognition is more suitable than all other standard methods because the vein patterns are difficult to forge and its acquisition process is easy. The proposed system is one of the biometric technique which introduces the design and implementation of a system using multiple algorithms for selecting ROI and to estimate the image ROI, edge and morphological filtering for feature extraction. These algorithms give good accuracy for the specified region of interest. The proposed results have been improved when compared to the existing results. The entire system will be developed in MATLAB.

***IndexTerms* - Biometrics, Dorsal veins, Multimodal, Feature extraction, Evaluation metrics, Hybrid Algorithms.**

I. INTRODUCTION

The term biometric is originated from the union of two Greek terms "bio" means "life" and "metrics" means "measure". Biometric systems are of two types, one is behavioral that deals with the behavioral patterns or traits of human body like gait, typing style, handwriting, speaking, and movement of body whereas second one is Physiological that deals with the physical appearance of the human body parts doesn't matter either these part are external or internal. For example, hand veins, retina, iris, palm, finger, foot, face etc. As security has become more valuable in different fields especially in highly protocol cases, that's why these biometrics systems are taken into account because they are unique from human to human and provide far greater security and reliability than other systems. The biometric systems are of two types. They are,

Unimodal: For authentication process, it depends on the proof of a single source of information. But these systems are not having enough performance and reliability.

Multimodal: It integrates, the multiple modalities information which arrives at decision. It overcomes the environmental variations and imposter attacks by elevating the performance and robustness of the system.

There are many methods that are designed in order to fulfill the security, reliability, and high performance criteria by using human biometrics. The oldest technique among these systems is "Facial Recognition System" that was designed to identify a person in a crowd. Other Biometrics systems used for authentication are handwriting, fingerprint, voice and so on. System that uses fingerprint for authentication and identification is used mostly due to low price and ease of use and identification. People brought implementation closer to eye like Iris and Retina scan because they have better results than voice, handwriting, facial and fingerprint. One step forward to this implementation people used human hand veins for identification process and so do we.

Human vein patterns are unique to every individual and provide a good constraint to differentiate a person from others, even in twins. It is very easy to get the pattern of dorsal hand veins because hand veins absorb more light than other tissues and gives a prominent image that is enriched in information and easy to classify. The vein structure's view depends on many factors such as: skin thickness, person's age, surrounding temperature and a physical activity done by the person and other surface conditions like

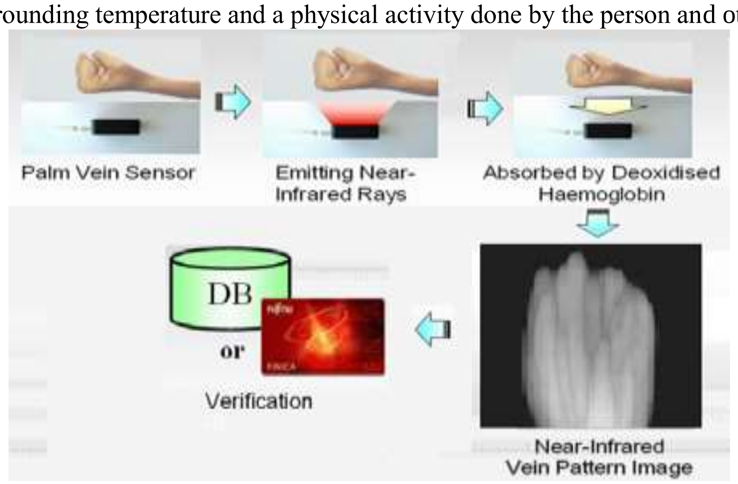

Fig.1: Processing steps of Dorsal hand vein recognition system

warts, moles, injury scars, hairs, etc. Imaging technologies that are used to acquire images of hand veins are of two types: first one is Far-Infrared (FIR) technology that has spectrum ranges between 8-14 micrometer and effective in capturing the large veins on the back side of hand but it is very sensitive to surrounding conditions due to which it cannot result a good and information enriched image. Second technology is Near Infrared (NIR) technology that has a spectrum ranges from 700-1000 nanometer yielding better and information enriched and stable images of veins present in a palm, hands, and wrist. NIR provides good images even in surrounding temperature and body condition changes.

II. EXISTING SYSTEM

The existing system is on image processing like Acquisition of a database, Storage of database, Live Acquisition of image and comparing these images with database.

Initially required users are authorized by training images by knuckle profile extraction, ROI extraction and feature extraction. Then the user is allowed to scan his dorsal hand from which the image is acquired using an NIR camera. Then the image is changed to grayscale and then binarized using Otsu's Thresholding method. After this, final knuckle profile is extracted by performing the edge detection method on the image and then Region of Interest (ROI) Extraction is done. After necessary cropping is done for ROI, Adaptive Histogram Equalization (AHE) is performed to get a contrast strectched image. The noise reduction techniques used are Median Filtering or LOG Filtering. This image is then morphologically thinned to get the vein patterns, which reveal the necessary bifurcation points and end points. From these minutae points, the Delaunay's triangulation is performed. Now after the Delaunay's triangulation, the image is matched with existing database of user's data and the decision of authorized or unauthorized user is taken based on the matching of matrices.

III. PROPOSED SYSTEM

The training of the dataset remains same but the input image is processed in a different manner i.e., initially the hue, saturation and intensity components in the image are separated. Then thresholding and Knuckle profile extraction are performed. ROI extraction is done by applying the quaternion fourier transform (QFT) & inverse quaternion fourier transform (IQFT). Then sharpening process is performed on extracted image by using Butterworth high pass filter with high frequency emphasis. Further the image is processed by Gaussian filter to eliminate the unwanted areas of ROI image. We get 1-pixel thick vein patterns by performing the morphological thinned operation. For removing the noise or high frequency components, median filter is used. Then the minutae extraction is performed i.e., bifurcation and end points are extracted. On these extracted minutae points, delaunay's triangulation technique is performed. After this, a specific GUI (Graphical User Interface) is built in MATLAB for matching purpose whether the scanned user data is present in database or not. If the user data presents it shows "Authorized user", otherwise it shows "Un Authorized user".

Also the parameters like accuracy, sensitivity, specificity, precision, recall, f-measure and gmean are extracted for evaluating the performance of existing and proposed systems.

Accuracy: Accuracy refers to the measure of degree to which the result of a measurement, calculation or specification confirms to the correct value (or) a standard value. Its Value must be high.

i.e..accuracy = (tp+tn) / (tp+fp+tn+fn)

Where, (tp+tn) refers correctly predicted class
(tp+fp+tn+fn) refers total testing class
tp & tn is no.of.true positives and true negatives
fp & fn is no.of.false positives and false negatives

Precision: Precision refers to the closeness of two or more measurements to each other. Its value must be high.
i.e..precision = tp/(tp+fp)

Sensitivity: The sensitivity of a test is its ability to determine the authorized user correctly. Its value must be high.
i.e.. sensitivity = tp/(tp+fn)

Specificity: The specificity of a test is its ability to determine the authorized user correctly based on true negative or opposite cases. Its value must be low.
i.e..specificity = tn/(tn+fp)

Recall: It is referred to as the true positive rate or sensitivity, and precision is also referred to as positive predictive value (PPV); other related measures used in classification include true negative rate and accuracy. Its value must be high.
i.e..recall = tp/(tp+fn)

f-measure: It is a measure of the test's accuracy in statistical context of binary classification. Its value must be high.
i.e.. f_measure=2*((precision*recall)/(precision+recall))

Gmean: It is the geometric mean is a type of mean or average, which indicates the central tendency or typical value of a set of numbers by using the product of their values (as opposed to the arithmetic mean which uses their sum). Its value must be minimum.

i.e..Gmean = sqrt(tp_rate*tn_rate)

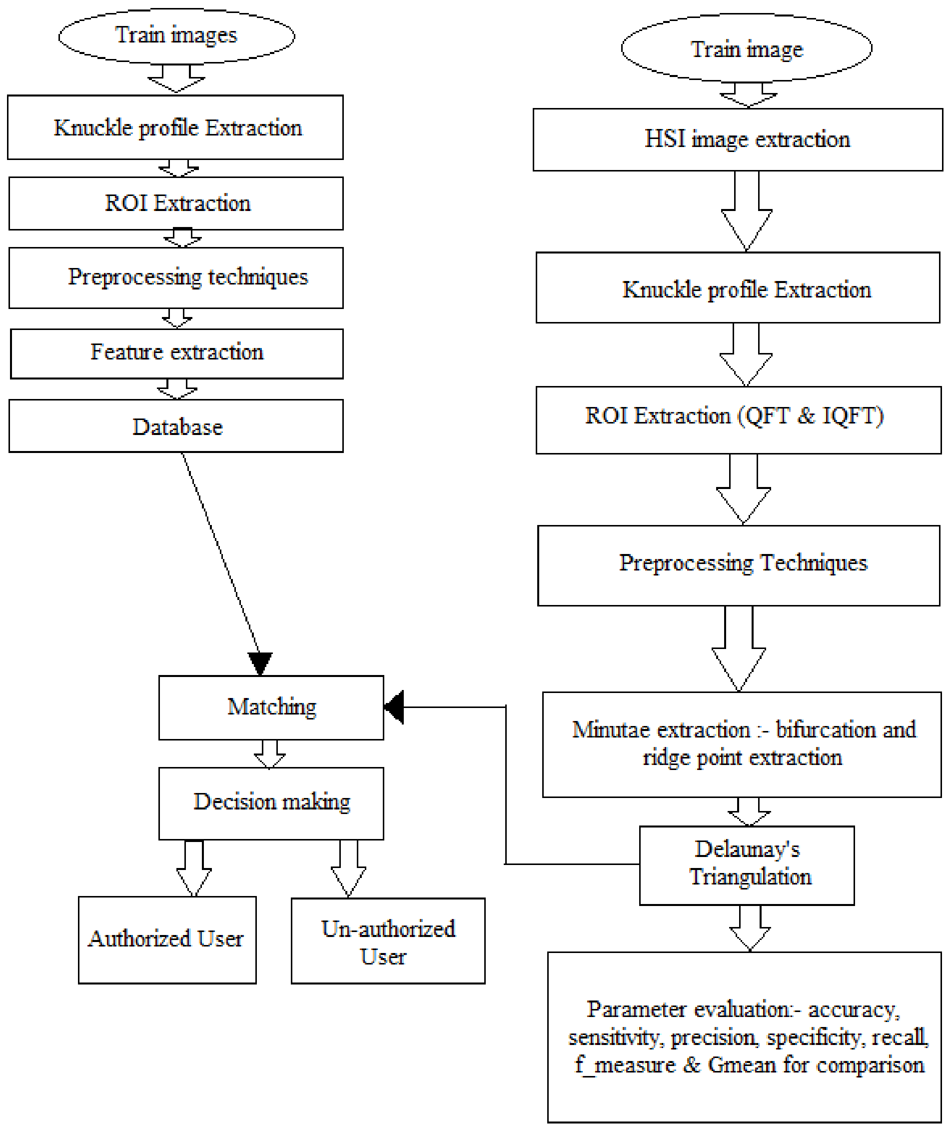

Fig.2: Proposed system block diagram

Initially the input image is converted to a HSI image, then using pure quaternions, the image can be represented in quaternion form as follows:

$$f(n,m)= H(n,m)\ \mu_1+S(n,m)\ \mu_2+I(n,m)\mu_3$$

Where,

(n,m) is the location of each pixel.

H(n,m), S(n,m) and I(n,m) are the Hue, Saturation and Intensity components of the pixel, respectively. The choice of μ is arbitrary. The generalized complex operator used in the Quaternion Fourier Transform, $\mu_3=\mu_1\ \mu_2$, $\mu_1\perp\mu_2$, $\mu_2\perp\mu_3$, $\mu_3\perp\mu_1$. f(n,m) is represented in symplectic form as,

$$f(n,m)=f_1\ (n,m)+f_2\ (n,m)\ \mu_2$$
$$f_1\ (n,m)=H(n,m)\mu_1$$
$$f_2\ (n,m)=S(n,m)+I(n,m)\mu_1$$

Then the Quaternion Fourier Transform can be calculated as,

$$F(u,v)=F_1\ (u,v)+F_2\ (u,v)\ \mu_2$$

$$F(u,v) = \frac{1}{\sqrt{MN}} \sum_{m=0}^{M-1} \sum_{n=0}^{N-1} e^{-\mu_1 2\pi\left(\left(\frac{mv}{M}\right)+\left(\frac{nu}{N}\right)\right)} f_i(n,m)$$

For $i\in\{1,2\}$, $f_i(n,m)$is calculated by f(n,m). The size of image is M×N. F(u,v) Can be represented in polar coordinates as,

$$F(u,v)=|F(u,v)|\ e^{(\mu\phi(u,v))}$$

Where, $\phi(u,v)$ is the phase spectrum and
$|F(u,v)|$ is the amplitude.

The phase preserves the edge information. But its ability to highlight features is limited, so the power of position information should be boosted further by using Butterworth high-pass filter (BHPF) with high-frequency-emphasis to make frequency information higher from amplitude spectrum. A 2-D BHPF of order n and cutoff frequency D0 is defined as,

$$H(u,v) = \frac{1}{1 + [D_o/D(u,v)]^{2n}}$$

Where, $D(u,v) = [(u - M/2)^2+(v - N/2)^2]^{1/2}$ is the distance between a point (u,v) in the frequency domain and the center of the frequency rectangle. Do=4% of image size and n=1.

The formulation of High Frequency Emphasis filtering is defined as,

$$H_e(u,v)=\delta H(u,v)$$

Where,

$$\delta = K/(\sum_{m=0}^{M-1}\sum_{n=0}^{N-1}\left(SMAP(n,m)\right)^2/(M \times N))$$

Through test, suitable K is 0.16. SMAP(n,m) is the initial saliency map with δ=1. The inverse Fourier transform is given by,

$$f_i(u,v) = \frac{1}{\sqrt{MN}}\sum_{m=0}^{M-1}\sum_{n=0}^{N-1} e^{\mu_1 2\pi\left(\left(\frac{mv}{M}\right)+\left(\frac{nu}{N}\right)\right)} F_i(n,m)$$

The output image can be constructed in the spatial domain by,

$$f'(n,m)=x(n,m)\,\mu_1+y(n,m)\,\mu_2+z(n,m)\,\mu_3$$

Where, $f'(n,m)$ is converted to grayscale to become initial saliency map.

A Gaussian pyramid is used for the ROI, which is a technique used in final saliency map generating. Gaussian pyramid decomposition will produce a progression of pictures in which each picture is a low-pass-filtered copy of its predecessor. The low-pass filtering is performed by means of convolution utilizing a Gaussian channel portion and down-sampling operator. At that point we utilize a threshold to change the saliency map into a binary mask, where ones refer to the ROIs. The final detection result (ROI) is generated by multiplying the mask in the original image. Then the remaining procedure is same as that of existing system. But due to the use of QFT, we obtain better extraction of features.

IV. SIMULATION RESULTS

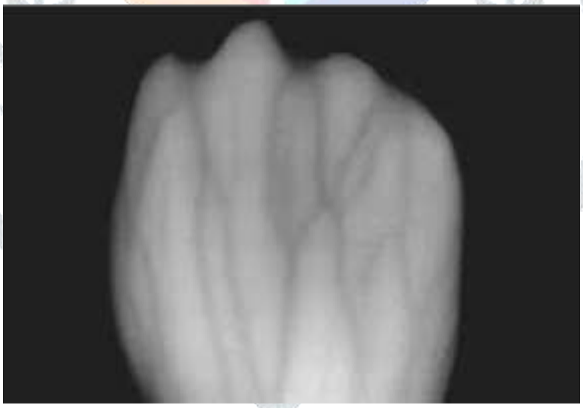

Fig.3: input image

In Fig.3, Images can be acquired using an NIR camera or take the images from internet as Input Image. These input images are stored in database.

Fig.4: knuckle shape image

In Fig.4, the input image is processed in a manner i.e., hue, saturation and intensity components in the image are separated. At that point the picture is binarized utilizing Thresholding strategy, this partitions the image into Foreground and background pixels (allotting dark level as 0 and white level as 1). After this, Edge recognition is executed on this image to get the final knuckle profile.

Fig.5: ROI image

In Fig.5, shows that ROI can be extracted and selecting the appropriate region by applying QFT and IQFT. After this, the unwanted regions in ROI extracted image is eliminated by using Gaussian filter. Then Butterworth high pass filter with high frequency emphasis is applied for sharpening the extracted image. The AHE (Adaptive Histogram Equalization) is performed to get a contrast image. By performing AHE technique, noise increases. Then, Median Filter is used to reduce the increased or unwanted Noise.

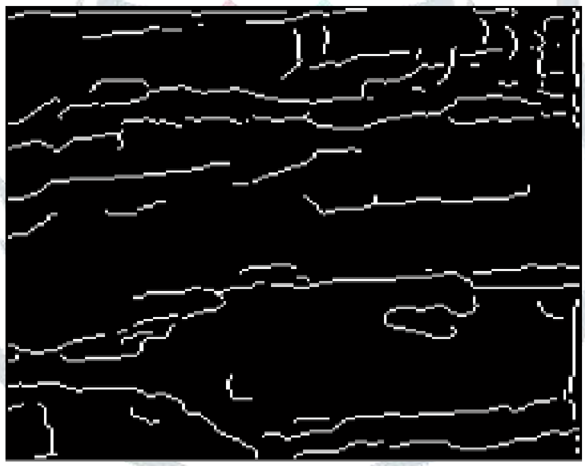

Fig.6: Thinned image

In Fig.6, We get 1-pixel thick vein patterns by performing the morphological thinned operation.The following image will reveal necessary bifurcation and end points.

Fig.7: Ridge end points

Ridge end points reveal in Fig.7, if a specific point on the vein has just a single pixel around in its 8-neighborhood, at that point the pixel will be an "ridge end point".

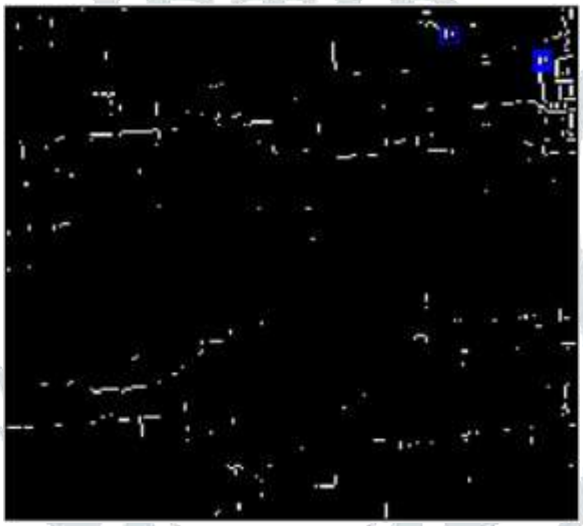

Fig.8: Bifurcation points

Bifurcation points reveal in Fig.8, in an image if a specific point on the vein has excess of two pixels in its 8-neighborhood, at that point the pixel will be a "bifurcation point".

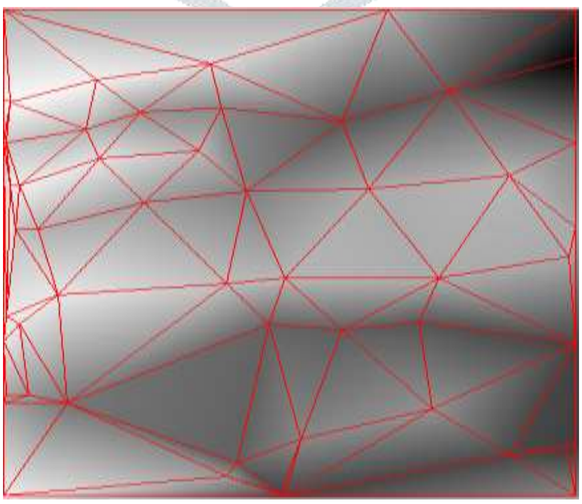

Fig.9: Delaunay's Triangulation and ridge end point triplets

In Fig.9, we apply Delaunay's triangulation technique to the obtained ridge end points. By this triangulation method, we get the ridge end point triplets. Delaunay's Triangulation is a method in which triplets are formed with respect to adjacent points in the given area.

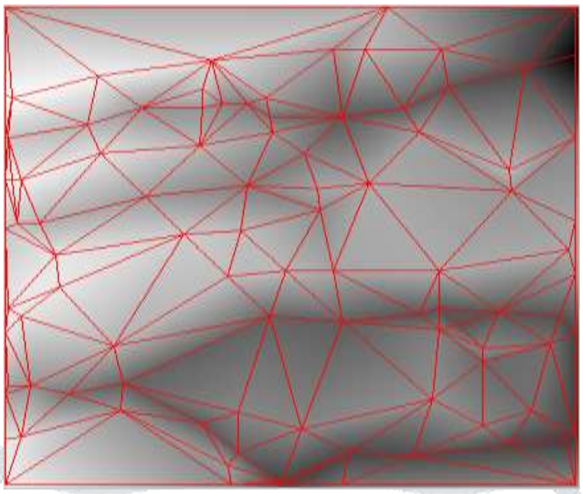

Fig.10: Delaunay's Triangulation and bifurcation point triplets

Similarly in Fig.10, we apply Delaunay's triangulation technique to the obtained bifurcation points. By this triangulation method, we get the bifurcation point triplets which are used for matching purpose. These ridge end point triplets and bifurcation point triplets are stored in database for further matching purpose.

a) Authorized user

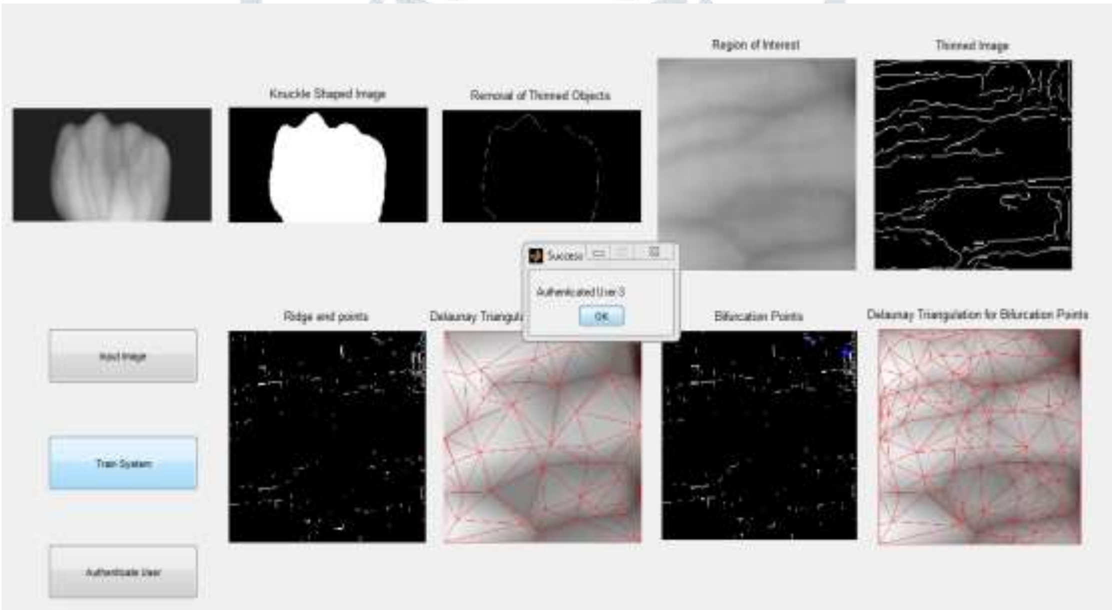

Fig.11: GUI Interface of Authorized User

The Fig.11, shows the least Difference or Threshold is decided (Ideally should be '0') and if an image within that threshold is found in comparison to the input image, then the input image is said to be an image from an "Authorized User".

b) Un-Authorized user

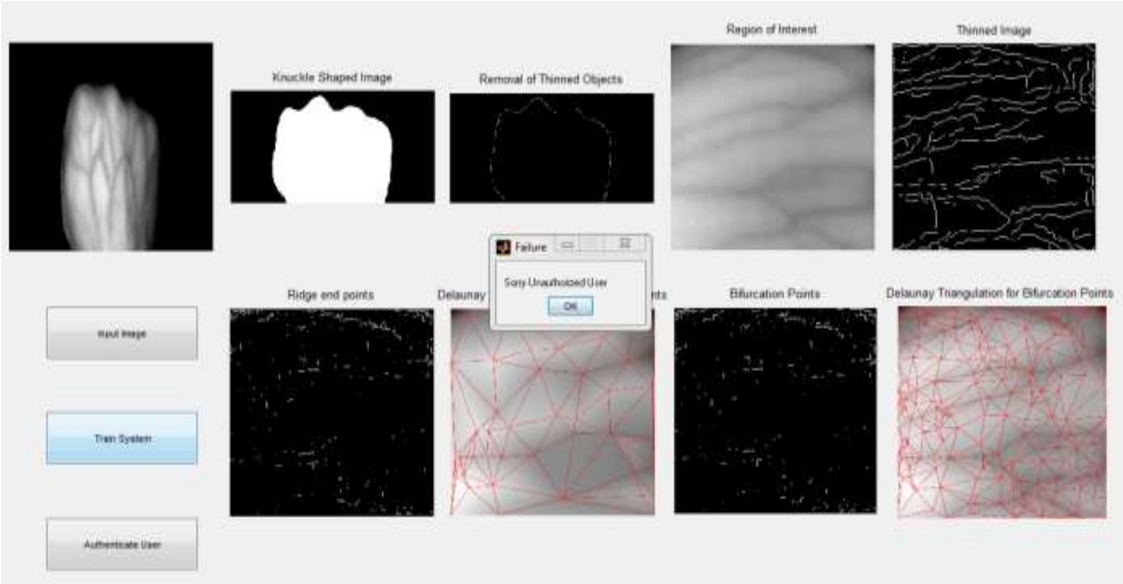

Fig.12: GUI Interface of Un-Authorized User

Similarly in Fig.12, shows the other one that is un-authorized user which means that user template is not found in the database. The parameters for proposed system are extracted for evaluating the performance of system.

Table 4.1: Parameter Results (Proposed)

parameter	Image 1	Image 2
Accuracy	0.8206	0.3456
Sensitivity	1	0.4466
Specificity	0.1313	0.3762
precision	0.8206	0.6044
f_measure	0.9014	0.5137
gmean	0.0072	0.0061
recall	1	0.4466

Similarly, the parameters for existed system are extracted for evaluating the performance of system.

Table 4.2: Parameter Results (Existed)

parameter	Image 1	Image 2
Accuracy	0.5554	0.2987
Sensitivity	0.8901	0.1245
Specificity	0.5554	0.6156
precision	0	0.3708
f_measure	0.7100	0.1864
gmean	0.2800	0.2768
recall	0.5010	0.1245

TABLE 4.3: Comparison parameters of existing and proposed methods

parameter	Existing Results		Proposed Results	
	Image 1	Image 2	Image 1	Image2
Accuracy	0.5554	0.2987	0.8206	0.3456
Sensitivity	0.8901	0.1245	1	0.4466
Specificity	0.5554	0.6156	0.1313	8.3762
Precision	0	0.3708	0.8206	0.6044
f_measure	0.7100	0.1864	0.9014	0.5137
Gmean	0.2800	0.2768	0.0072	0.0061
Recall	0.5010	0.1245	1	0.4466

V. CONCLUSION

Dorsal hand vein pattern offers more security, Accuracy, and Non-contact as well as low maintenance system is achieved, so it is more advantageous over other biometric systems. By applying Hybrid processing algorithms, we are getting better result & accuracy than existed method. So, the better performance and more security can be achieved by mulitimodal biometric system than unimodal system. The biometrics future can perhaps be a Multimodal biometric system than unimodal systems because as they overcome few of the problems observed in unimodal biometric systems.

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