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Multimodal Biometric Authentication at Feature Level Fusion

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Abstract:

Biometric recognition technology provides a secure method of recognition that cannot be stolen, misplaced or forgotten.Unimodal biometrics is affected by many problems like noise in sensor data, spoof attacks, non universality. The problems in unimodal biometrics are resolved in multimodal biometrics. It is providing better accuracy in recognition. I present an innovative technique in which input images of iris and finger print images are preprocessed using techniques like contrast enhancement, filters to improve the quality of the image. Subsequently, features from the iris and fingerprint are extracted using LBP and LGXP. Features extracted from two images are fused at feature level extraction module.GSO algorithm is used for optimal selection of features. Selected features are fused and given to optimized neural network for recognition.

Index Terms: Feature extraction, Local Binary Pattern, feature selection, Group search Optimization, 0ptimized neural network

Introduction: Security means protection of person, organizations, buildings from attacks. In most public areas like railway stations, bus stops, airports require more security measures. Verification of human was carried out using passports, passwords, ID cards but these are easily forgotten, lost, stolen. Human beings have different unique characteristics. These unique characteristics are used in biometric technology to authenticate a person. Biometrics is the measurement and statistical analysis of people's physical and behavioral characteristics. It is secure method of recognition that cannot be stolen or forgotten. The unimodal biometrics rely on single source of information. The limitations of unimodal biometrics are noise in sensed data, non universality, spoof attacks. Each biometric trait has weaknesses and strengths. The main drawback with unimodal biometrics is physical characteristics of a person may not be available always. These limitations can be overcome by multimodal biometrics. Combination of two or more biometrics is referred as multimodal biometrics. With the multimodal biometrics accuracy, reliable recognition, security has been increased, Vulnerability is decreased.

In this paper we presented an innovative techniques for iris recognition, fingerprint recognition and fusion of features at feature level module.

Iris recognition: Iris recognition is a method of identifying people based on unique patterns within the ring-shaped region surrounding the pupil of the eye. The iris usually has a brown, blue, gray, or greenish color, with complex patterns that are visible upon close inspection. Iris recognition is non invasive technology. The only internal organ which is externally visible is iris. The features of iris remain stable throughout the life. Iris helps to control the amount of light entering through the pupil. It is one of the most reliable and accurate biometric feature. From a digitized image unique pattern can be obtained using digital image processing. Unique pattern template is stored in database. When a person is to be recognized by iris recognition system, eye is photographed and

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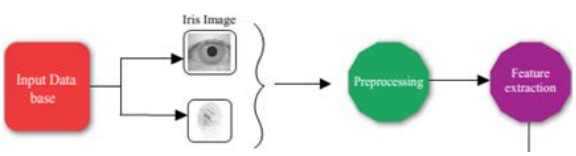
template is made from the iris image. This template is checked with database until matching template is found, if template matches person is identified as authenticated person otherwise person remains unidentified person[1].

Fingerprint recognition: Fingerprint is an impression on a surface by persons fingertip. Fingerprint recognition became popular due to low cost, accuracy. Fingerprint consists of ridges and valleys. The dark area of fingerprint are ridges and the valleys are the white areas. A fingerprint scanner system has two basic jobs -- it needs to get an image of your finger, and it needs to determine whether the pattern of ridges and valleys in this image matches the pattern of ridges and valleys in pre-scanned images. The image in figure 1 shows fingerprint and features of fingerprint [5].

Figure 1:fingerprint image



Biometric authentication is done at three modules: (1)pre processing module (2)feature extraction module (3)recognition module. Initially iris recognition is carried out by using above three modules then it carried out by fingerprint recognition using the same above three modules. Finally, multimodal biometrics authentication is carried out by the above mentioned modules. The above diagram shows the block diagram of proposed method.

preprocessing of iris and fingerprint : An image is two dimensional signal. It is represented in the form f(x,y).The value f(x,y) denotes a pixel value at that point. Image is two dimensional array values between 0 to 255.Thousands of pixels form a image. Total number of pixels = number of rows (X) number of columns. The number of different colors of an image depends on bits per pixel i.e2^{bpp}. The pixel value with 0 denotes black color. The pixel with value 2^{bpp} -1 denote white color. Gray color is mid point value between black and white. The aim of preprocessing is improvement of image data that suppresses unwanted distortions or enhance some image features important for further processing. Preprocessing operations do not increase image information content but they decrease. The aim of pre-processing is an improvement of the image data. Irrelevant parts of the image can be removed by image cropping. Black and white images have only two colors. A gray level image is simply one in which the only colors are shades of gray. The reason is less information needs to be provided for each pixel. In fact a `gray' color is one in which the red, green and blue components all have equal intensity in RGB space, and so it is only necessary to specify a single intensity value for each pixel, as opposed to the three intensities needed to specify each pixel in a full color image. The grayscale intensity is stored as an 8-bit integer giving 256 possible different shades of gray from black to white. The matlab function used to convert color image to gray level image.

```
img = imread('iris.jpg');
gray = rgb2gray(img);
imshow(gray);
```

Histogram is graphical representation of numeric data. imhist(I) calculates the histogram for the intensity image I and displays a plot of the histogram. The number of bins in the histogram is determined by the image type. The bins are usually specified as consecutive, non-overlapping intervals of a variable. The bins (intervals) must be adjacent, and are usually equal size. The matlab function for histogram is

```
I = imread('pout.tif');
imhist(I)
```

Histogram equalization is a method in image processing of contrast adjustment using the image's histogram. The histogram equalization is applied to the input image. Here, each and every pixel is substituted by integral of the histogram of the image in the corresponding pixel. By using this, the intensities will be distributed on the histogram. With the result, the regions having the lower local contrast achieves the superior contrast. The histogram equalization carries out this by effectively spreading out the most recurrent intensity values.

```
I = imread('iris.jpg');
J = histeq(I);
imshow(I);
figure, imshow(J);
```

Images are affected with noise. Mean filtering is simple and effective method to reduce the noise. Mean filtering is simply is replaces each pixel value in an image with the mean (`average') value of its neighbors, including itself. 3×3 square kernel is used.

Feature extraction: Feature is a piece of information which is used for solving specific application. The most commonly used features in images are edge and boundary features **:** An edge can be defined as a set of contiguous pixel positions where an abrupt change of intensity values occur. There are three types of edges horizontal edge, vertical edge, diagonal edges. Edge detection reduces amount of data and filters out unimportant information, preserving important data. Some of the edge detection operators are prewitt, sobel , laplacian operators. color features: Color is visual attribute of object that is resulted from the light emitted or reflected from the histogram color features are extracted. These color features are mostly used in cancer detection. Shape features: The physical structure of an object refers to shape. Area, perimeter, orientation are the sum of the properties considered for shape feature extraction. Texture features**:** it refers to the surface characteristics and appearance of an object given by the size, shape, density. Texture feature extraction is to collect above mentioned features. Texture features are considered to classify the image more accurately. Texture analysis is widely used in medical image processing, document processing, recognition Statistical methods, model based methods, transformation methods are some of the methods in texture feature extraction. Transformation methods includes fourier transforms, wavelet transformation methods. In this paper textures features of both iris and finger print are considered [16].

Feature extraction plays an important role. The purpose is to reduce the original dataset by measuring certain properties. Feature extraction a type of dimensionality reduction that efficiently represents interesting parts of an image as a compact feature vector. This approach is useful when image sizes are large and a reduced feature representation is required to quickly complete tasks such as image matching and retrieval[7]. The extracted features are expected to contain the relevant information from the input data, so that the desired task can be performed by using this reduced representation instead of the complete initial data. Common feature extraction techniques include Histogram of Oriented Gradients (HOG), Speeded Up Robust Features (SURF), Haar wavelets, and color histograms. In this we presented Local Binary Patterns (LBP) and LGXP for feature extraction.

Local Binary Patterns (LBP):LBP is very efficient texture operator.LBP operator became very popular in many applications. The following are the steps applied in LBP[15].

1.First convert bitmap image to gray level image.

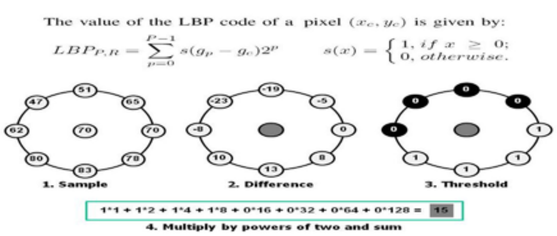
2.Divide the window into cells.(8x8 or pixels in a cell)

3.For each pixel in a cell, compare the pixel with 8 neighbors.

4.If the center pixel value is greater than neighbor value write 0, otherwise 1.This process gives 8 digit binary number.

5.Compute the histogram.

6.Concatenate histograms of all cells. We get the feature vector of entire window. We store count of each LBP for this texture. There are 36 unique LBPs for image with 256 grey level. So, we have 36 features.



Local Gabor XOR Pattern LGXP: The phase part of Gabor followed by LBP gives LGXP. In LGXP, phases are quantized into ranges. Quantization dividing into quanta (partitions). The LGXP operator is applied to quantized pixels of the center pixel and neighboring pixels [16].

$$q(\varphi_{\mu,w}(l)) = i$$

$$if\ \frac{360*i}{c} \leq \varphi_{\mu,w}(l) < \frac{360*(i+1)}{c}, i = 0,1,...,c-1.$$

Matrix with initial phase of the pixels

95	32	14
21	13	78
15	18	25

Matrix after quantization

1	3	1
2	1	0
1	2	2

$$LGXP^{i}_{\omega,v} = q(\varphi_{\omega,v}(H_c)\ \ XOR\ q(\varphi_{\omega,v}(H_i))$$

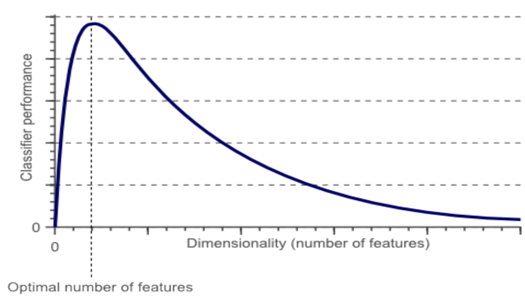
$LGXP^{i}_{\omega,v} = (P = 1,2.....p)$ denotes the pattern determined between $\phi_{\omega,v}(l)$ and its neighbor H_i is evaluated as illustrated below. Here, $\varphi_{\omega,v}(H_c)$ denotes the phase and $q(\varphi_{\omega,v}(H_i))$ represents the quantized value of the phase and where $\phi_{\omega,v}(l)$ depicts the central pixel position in the Gabor phase map with scale w and orientation ω, p represents the dimension of neighborhood. At last, the consequential binary labels are concatenated jointly as the local pattern of the central pixel.

$$LGXP_{\omega,v}(H_c) = [LGXP^{p}_{\omega,v}, LGXP^{p-1}_{\omega,v}, ..., LGXP^{1}_{\omega,v}]_{binary}$$

$$= \sum_{i=1}^{p} 2^{i-1}, LGXP^{i}_{\omega,v}$$

0	1	0
1	0	1
0	1	1

after XOR comparison with center quantized value. Binary value obtained is 01011101.Equivalent decimal value is 93. **feature selection:** As the dimensionality increases, the classifier’s performance increases until the optimal number of features is reached. Further increasing the dimensionality without increasing the number of training samples results in a decrease in classifier performance [17].



The extracted features are given to the Group Search Optimization algorithm for choosing the optimal features [17].

GSO algorithm: 0ptimal features of both iris and finger print can be selected using GSO algorithm. Group search optimizer (GSO), which is inspired by animal behavior, especially animal searching behavior. It is based on producer scrounger model. it is population based optimization algorithm. Animals in the group use one of three strategies: producer, it means, searching for food for themselves and then eating it; scrounger, it means, never searching for food but rather surveying the producers and always joining to consume part of each discovery; and opportunist, that is, searching for food and surveying the producers concurrently and feeding from both sources as detected. We assume that each individual is a pure strategist, i.e,it uses only one of the three strategies described above and does not alternate between them. In a group of N individuals, the proportions of producers (p), of scroungers (q), and of opportunists (r), where p + q + r = 1.The population is called a group and each individual in the population is called a member.

Initialization. For convenience, the related symbols are summarized as follows [19]: in a 𝑛-dimension search space, the 𝑖th member at the 𝑘th iteration has a current position 𝑋𝑘 𝑖 ∈ R𝑛 ; a head angle 𝜑𝑘 𝑖 = (𝜑𝑘 𝑖1 ,...,𝜑𝑘 𝑖(𝑛−1)) ∈ R𝑛−1, and a search direction of the 𝑖th member which is a unit vector 𝐷𝑘 𝑖 (𝜑𝑘 𝑖) = (𝑑𝑘 𝑖1 ,...,𝑑𝑘 𝑖𝑛) ∈ R𝑛 ; the unit vector can be calculated as [20] 𝑑𝑘 𝑖1 = 𝑛−1 ∏ 𝑞=1 cos (𝜑𝑘 𝑖𝑞) 𝑑𝑘 𝑖𝑗 = sin (𝜑𝑘 𝑖(𝑗−1)) 𝑛−1 ∏ 𝑞=𝑗 cos (𝜑𝑘 𝑖𝑞) (□ = 2, . . . , □ − 1) □□ □□ = sin (□□ □(□−1)) , (6) where the □□ □ , □□ □ , and □□ □ are randomly generated for the initialization of group. For simplifying the algorithm computational capability, we assume that there is only one producer (here we select the best member as the producer) at each iteration for calculating the group member’s fitness value. The producer will randomly scan three points for getting the best point at zero degree, the point represents

Find the producer Z_p of the group

- Producer performance

iteration may be described as given below.

(i) It carries out the scanning assignment at zero degree

$$Z_z = Z_p^s + \varepsilon_1 d_{\max} L_p^s\left(\Psi^s\right)$$

Where, d_{max} denotes the maximum search distance.

(ii) It accomplishes the scanning function at the right hand side hypercube

$$Z_r = Z_p^s + \varepsilon_1 d_{\max} L_p^s\left(\Psi^s + \varepsilon_2 \Phi_{\max}/2\right)$$

(iii) It executes the scanning task at the left hand side hypercube

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$$Z_l = Z_p^s + \varepsilon_1 d_{\max} L_p^s \left(\Psi^s - \varepsilon_2 \, {}^{\Phi_{\max}}\!\!/_{2} \right) \qquad (13)$$

Where, ε_1 points to a normally distributed random number with zero mean and unity standard deviation and ε_2 stands for a uniformly distributed random sequence which has values within the range 0 and 1.

The maximum search angle $\Phi_{\max}$ is effectively represented as:

$$\Phi_{\max} = \frac{\pi}{c^2}$$

Now, the constant *c* can be furnished as:

$$C = round(\sqrt{n+1})$$

Here, n corresponds to the dimension of the search space.

$$\therefore \Phi_{\max} = \frac{\pi}{n+1}$$

The evaluation of maximum search distance d_{max} includes the ensuing equations.

$$d_{\max} = \| d_U - d_L \|$$

$$d_{\max} = \sqrt{\sum_{i=1}^{n} (d_{Ui} - d_{Li})^2}$$

Here, d_{Ui} and d_{Li} represent the upper and lower limits of the *i*th dimension, correspondingly.

The best location consisting of the most beneficial resource may be achieved by means of above equations. The existing best location will give way for a new best location, if its existing resource is found to be inferior to that in the new location. Otherwise, the producer preserves its location and turns its head as per the head angle direction which is randomly produced by means of Equation (18).

$$\Psi^{s+1} = \Psi^s + \varepsilon_2 \tau_{\max}$$

Here, τ_{max} corresponds to the maximum turning angle which is evaluated with the help of the equation given below.

$$\tau_{\max} = \frac{\Phi_{\max}}{2}$$

When the producer is unable to identify a better position even after the completion of *m* iterations, its head would then assume its initial position as given in equation (20).

$$\Psi^{s+c} = \Psi^s \qquad (14)$$

Scrounger performance

In all the iterations, many members other than the producer are selected and they are termed as scroungers. The scrounging action of the GSO generally includes the area copying task. During the *s*th iteration, the function of area copying which the *i*th scrounger carries out may be shaped as a movement to inch towards the producer in an intimate manner which is illustrated as:

$$Z^{s+1} = Z_i^s + \varepsilon_3 o (Z_p^s - Z_i^s)$$

Here, o specifies the Hadamard product which determines the product of the two vectors in an entry-wise manner and ε_3 denotes a uniform random sequence lying in the interval of (0, 1). The *i*th scrounger continues to be in its searching task so as to make a selection of the superior chance for the purpose of linking.

- Ranger performance

The rangers are the residual members of the group, which have been relocated from their current location. They are competent to efficiently locate the resources by carrying out arbitrary walks or by means of an orchestrated searching process. The arbitrary talks are favored in cases, where the resources located are to be appropriately allocated. Both the head angle and the distance related to the ranger are created in an arbitrary manner.

$$d_i = c.\varepsilon_1.d_{\max}$$

T

he arbitrary walk to a novel point may be illustrated as:

$$Z^{s+1} = Z_i^s + d_i\, L_i^s\left(\Psi^{s+1}\right)$$

When the whole procedure comes to an end, the fitness of the modernized solution is estimated. The best solution is achieved, if the procedure is replicated for's' number of iterations. In accordance with these, the extracted features are optimally chosen and are identified by means of the optimized neural network.

Begin

Initialize: Randomly initialize positions X_i and head angles φ_i of all members.

Calculate: Calculate the fitness values of initial members

While termination conditions are not met **do**

For each members i in the group **do**

Find new search solution using the following eq.

$$X_i^{k+1} = X_i^k + \omega_1(X_i^k - X_d^k) + \phi_i(Y_j^k - X_i^k)$$

Select Producer: Find the producer of the group.

Producer Strategy: (i) Scan at three random points in the scanning field using eq. (2) to (4).

(ii) Move to the best point if it has a better resource, otherwise stay at the current position and turn the head to a new angle using eq. (6). (iii) If a better area cannot be found then turn the head back to zero degree using (eq.7).

Scrounger Strategy: Select a number of group members (normally 80% of the members) as scroungers. Then perform scrounging using (eq.8).

Ranger Strategy: The rest of the members (rangers) will perform ranging.

Calculate the fitness value of each member from this group.

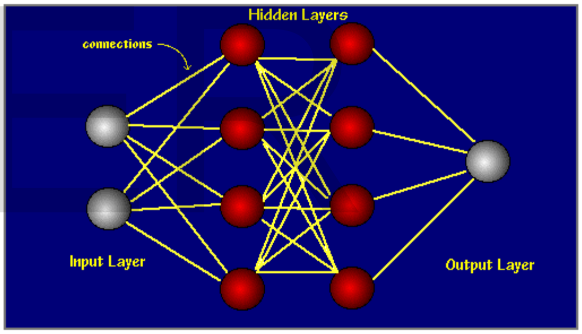
End For

End While

End

The target value is fixed and in accordance with the target value the images are identified. Then, the relative feature value is obtained

Recognition for iris and fingerprint: After the features are selected the features are identified with the help of the artificial neural network. Neural neworks are typically organized in layers. Layers are made up of a number of interconnected 'nodes' which contain an 'activation function'. Patterns are presented to the network via the 'input layer', which communicates to one or more 'hidden layers' where the actual processing is done via a system of weighted 'connections'. The hidden layers then link to an 'output layer' where the answer is output as shown in the graphic below.



In our proposed method we use three input neurons, one hidden layer with twenty neurons and one output layers are used for recognizing purpose. In the artificial neural network the weights are optimized with bat algorithm. The steps are as follows.

- The loads for each and every neuron are attached separately from the neurons in the input layer.
- The neural network is enlarged with the chosen feature value as the input units, $\{H_u\}$ as the Hidden units and O as the output unit.
- Net input is calculated as below

$$I = \sum_{n'=0}^{H_{NH}-1} w_1\ f_1 + w_2\ f_2 + w_3\ f_3 + ... + w_n\ f_n$$

The activation function for the output layer is

$$Active\ (I) = \frac{1}{1+e^{-I}}$$

Bat algorithm: It is based on echolocation behavior of micro bats with varying pulse rates of emission and loudness. Mega bats does not use echolocation. Echolocation means that some bats have highly sophisticated sense of hearing. They emit a very loud sound pulse and wait for to bounce from the objects in their path, sending echo back to the boats. From this echo bats can determine the size of an object, how far they are, how far they are travelling, all in split of a second. Echolocation is used extensively in many micro bats. Bats fly randomly with velocity vi at position xi with a minimum frequency fmin, varying wavelength λ and loudness A0 to search for prey. They can automatically adjust the wavelength (or frequency) of their emitted pulses and adjust the rate of pulse emission r ϵ [0, 1], depending on the proximity of their target.The loudness can vary from A0 max to Amin

weight optimization using Bat algorithm:

Step by step procedure of bat algorithm:

Step 1: Initially, the bat population s_i (i=1,2,…,n) is initialized. Here the population is represented as the weight.

Step 2: Thereafter, the pulse frequency (f) and velocity (v) are initialized which is followed by the initialization of the pulse rate (r) and loudness (L).

Step 3: At this junction, the fitness is estimated with the help of the following equation.

$$fitness = \min imum\ error \quad (24)$$

Step 4: The new population is generated by adapting the frequency and modernizing the velocity by means of the following Relations.

$$f_i = f_{\min} + (f_{\max} - f_{\min})\gamma$$

$$v_i^{\ x} = v_i^{\ x-1} + (s_i^{\ x} - s_0) f_i$$

$$s_{new} = s_{old} + EL^x$$

Here, i= {1,2,…N} N denote the number of bats. E and ɤ represent arbitrary numbers, E & ɤ ϵ [0, 1]. S_{old} symbolizes the existing global best location. $L^x = \langle L_i^x \rangle$ refers to the average of loudness.fmin=0,fmax=100

$f_i = f_{min} + (f_{max} - f_{min})\beta$	• β ∈ [0, 1] • f_{min} = 0 & f_{max} = 100
$v_i^{t+1} = v_i^t + (x_i^t - x_*) f_i$	• x_* is the current global best location
$x_i^{t+1} = x_i^t + v_i^t$	• t is number of iteration

Step 5: If the arbitrary number exceeds the pulse rate, the solution is selected from among the best and a local solution is created around the best solution by flying randomly. Now the fitness is determined.

Step 6: If (rand<L_i and $f(s_i)<f(s_n)$), new solution is accepted by stepping up the pulse rate and scaling down the loudness. Thus, the best location is found out. With the help of the above cited procedures, the optimal weights are found out, followed by the accomplishment of the neural network process.

- Now the learning error is located.

$$Error = \frac{(desired\ output - obtained\ output)^2}{2}$$

The procedure is continued till the error is minimized.

Fusion: Fusion which is done before matching is known as pre classification, it includes sensor level fusion and feature level fusion. The fusion which is done after matching is known as post classification, it includes match score level fusion and decision level fusion. In this paper how iris and fingerprint are fused at feature level fusion is presented Multimodal biometric systems offer improvement in the matching accuracy of a biometric system depending upon the information being combined and the fusion methodology adopted. Thus, the FAR and the FRR of the verification system can be reduced simultaneously. The amount of information available to the system gets compressed as one proceeds from the sensor module to the decision module. Integrating information at an earlier stage of processing is expected to provide more accurate results than the systems that integrate information at a later stage, because of the availability of more richer information. Since the feature set contains much richer information on the source data than the matching score or the output decision of a matcher, fusion at the feature level is expected to provide better recognition performances[20].

fusion at feature level: The data obtained from each sensor is used to compute a feature vector. As the features extracted from one biometric trait are independent of those extracted from the other, it is reasonable to concatenate the two vectors into a single new vector. The new feature vector now has a higher dimensionality and represents a person's identity in a different. Feature reduction techniques may be employed to extract useful features from the larger set of features[21].

.**Feature level fusion** The extracted features from multiple sources are fused to form a new feature vector. Compared to other levels of fusion feature level is considered to be best since feature vectors contain rich information about the raw biometric data, it is expected to provide better efficiency. At the same time it is difficult to do fusion at this level. The following are the few reasons why fusion at this level is difficult (i)the feature vectors may not be compatible (ii)by combining the feature vectors to form a single feature vectors it results in curse of dimensionality i.e for a sample, if there are maximum number of features, dimensionality performance of classifier will be degraded rather than improve.

The feature values are fused based on the following procedure. For example, we got the feature value for iris is 1, 2, and 3. And the feature value for fingerprint image is a, b and c. These values are fused in below section,

Feature value for iris:

1	2	3

Feature value for fingerprint:

a	b	c

Fused feature value:

1	3	b

Here we select the feature value position with the interval two bases and then we fuse the feature value. Based on these in our proposed work the feature values are fused. As per the above-mentioned procedure the feature level fusion is carried out.

Results:

preprocessing of iris: The proposed method is implemented in MATLAB. Iris and fingerprint are inputs to the implementation. The following are sample image of iris and fingerprint.

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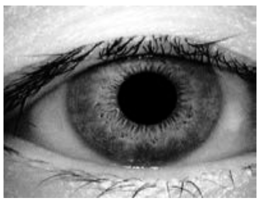
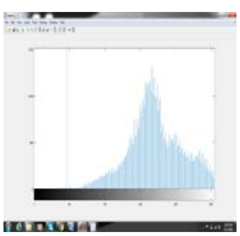
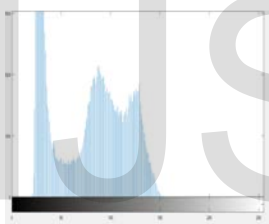
iris image fingerprint

Grayscale images for iris and fingerprint

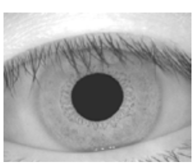


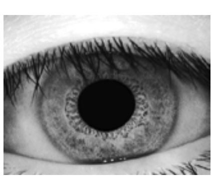

histograms of iris and fingerprint

iris fingerprint

After contrast enhancement(histogram equlization)

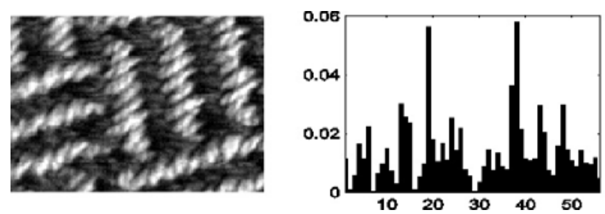


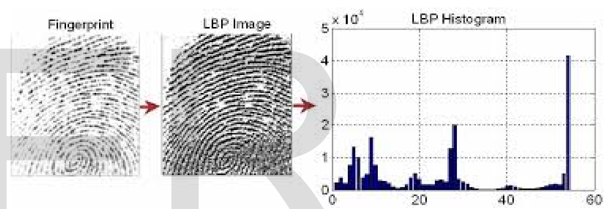




After applying mean filter

Feature extraction:

LBP:





Feature vectors using lbp and lgxp

Feature value									
956	345	530	319	1051	273	175	385	999	5025
1879	385	350	126	340	912	140	162	607	11349

Table-1 feature vectors of iris and fingerprint

Optimal feature value

Image	Feature value		
Iris	345	319	175
Fingerprint	385	126	140

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Table-2 optimal feature values of iris and fingerprint

Table-3 comparison of proposed feature level fusion method with existing method

Methods	Feature	FAR	FRR
Existing method [29]	Fused Image(iris and fingerprint)	2.3%	7.6%
Proposed Method	Fused Image(iris and fingerprint)	0.11%	0.11%

CONCLUSION: The multimodal biometric authentication using the iris and fingerprint images is discussed in the paper. The proposed feature level fusion method achieves 0.11% for FAR and 0.11% for FRR and the proposed score level method achieves 0.22% for FAR and 0.11% for FRR.

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