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Hybridization of Feature Level Fusion with Ant Colony Optimization in Multimodal Biometrics

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Abstract – In biometric system, multimodal biometrics provides stronger security as compared to unimodal biometrics. Even though multimodal biometric improves the accuracy and reliability of the system, but requires large memory storage and consumes numerous execution time due to use of high dimensionality datasets. Search is being an NP-hard problem in biometrics, which garnish an attention for research in biometric system. Due to NP-hard nature of searching in biometric, accurate solutions could not be discovered in limited time. Therefore, researchers use heuristic or random search methods such as PSO, GA, ACO and Cuckoo search etc. to obtain optimal or approximate optimal solutions for such problems. This paper proposes a hybrid approach of feature level fusion in biometric system with Ant Colony Optimization based feature sub selection method to aiming to improve performance. The median filter and morphological operations are used for pre-processing of finger vein and fingerprint images respectively. Confusion matrix plot with equal error rate and accuracy are the evaluation parameters.

Index Terms: ACO, KNN, Median Filter, Morphological Operations, Random Forest Classifier.

I. INTRODUCTION

Currently, biometrics is present in multiple applications such as secure access to computers, networks, databases, time control and physical access to restricted access rooms, among others.

State agencies have different types of information, in important volumes and with different levels of privacy. Access control to this information is generally carried out through traditional mechanisms such as access codes and magnetic cards [1].

Scientific research on biometrics begins at the beginning of the last century in order to find a system for the identification of persons for judicial purposes. With the beginning of these investigations, important advances take place and the morphological features unique to each person begin to be used for identification.

In this way, the physical characteristics of the human being have been used for more than a century in the forensic field of biometric evidence: Juan Vucetich, in 1891, made the world's first fingerprints with 23 fingerprints processed, then in 1905 his fingerprint system was incorporated by the Federal Police of Argentina.

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In 1941, Murrary Hill of Bell Labs began the study of voice identification and their work was taken and redefined by L. G. Kersta. In 1986, Sir Alec Jeffreys first used DNA to identify the author of murders in England [2] [3]. However, the use of biometric recognition as an automatic means of personal authentication in areas other than those mentioned previously, is a recent research and development area, motivated by the advancement in information and communications technologies (ICTs). The new identification technologies through biometric systems, are emerging as the future key that will allow us to open all doors. The main way to identify yourself in the 21st century will be our own body, our physical characteristics, unique and distinctive from those of any other human being.

For a long time now, most countries in the world use fingerprints as a practical and secure identification framework. In addition, new instruments for obtaining and verifying fingerprints have emerged in recent decades. Other morphological features are also used as variants of identification, such as iris, facial heat, body odor, among others [4] [5].

Biometric systems, based on physical or behavioural characteristics, are classified as static (based on physiological characteristics) and dynamic (based on behavioural characteristics). Among the first we can mention: the fingerprint [6], iris and retina, geometry and hand stripes [7], facial recognition [8], among others; and within seconds we can mention handwriting and written signature recognition, keyboard dynamics, voice recognition, among others [9].

Manufacturers are increasingly proposing, for problems requiring a great deal of security, to no longer use a single characteristic but to set up a system based on combinations of different biometric means in order to further increase safety.

Despite this rapid development, biometrics has points of imperfections. Indeed, at present, there are still very few reflections before the implementation of a biometric solution, whether at the level of the chosen method, the constraints imposed on users or the level of security chosen. There are sometimes aberrations: high-performance sensors coupled with obsolete recognition algorithms, all to control access to a school restaurant.

In addition to this lack of prior reflection, the other critical point of biometric systems concerns their reliability and the mechanisms of recognition or authentication to be implemented.

II. MULTIMODALITY

Multimodality is the use of several biometric systems. The combination of several systems aims to reduce the limitations seen previously. Indeed, the use of several systems is primarily intended to improve the recognition performance. By increasing the amount of discriminant information of each person, it is desired to increase the recognition power of the system. In addition, the fact of using several biometric modalities reduces the risk of impossibility of registration as well as the robustness to fraud.

The previous research works have utilized only dimensionality reduction methods, in which dimensions of feature space are reduced to overcome the space requirements. The previous research work presented by S.Kihel et al. [10] also utilized dimensionality reduction methods PCA and Kernel Fisher Analysis (KFA) to reduce feature space. The following problems are identified in S. Killeh's research work [10]:

- They could not ample focus on reduction of execution time.
- For large feature space, the number of features will be large.
- For large number of features, feature subset selection will consumes a lot of time which is not favourable for real-time biometric systems.

This research work proposes a hybrid approach of feature level fusion with Ant Colony Optimization (ACO) based feature subset selection technique to solve space and time complexity problems. The purpose is to select best features in optimal time by using ACO-based feature subset selection method and fusion at feature-level in multimodal biometric which will give better performance.

- To study the existing methods in the biometric recognition system.
- To design a multimodal biometrics of fingerprint and finger-vein biometric characteristics by fusion approach at the feature level.
- To estimate optimal space and time by using Ant Colony Optimization feature sub selection method and KNN and Random forest classifier as classifiers.
- To simulate the proposed work in MATLAB.

III. PROPOSED METHOD

A. System Model

Flow diagram for proposed approach is shown in Figure 1.

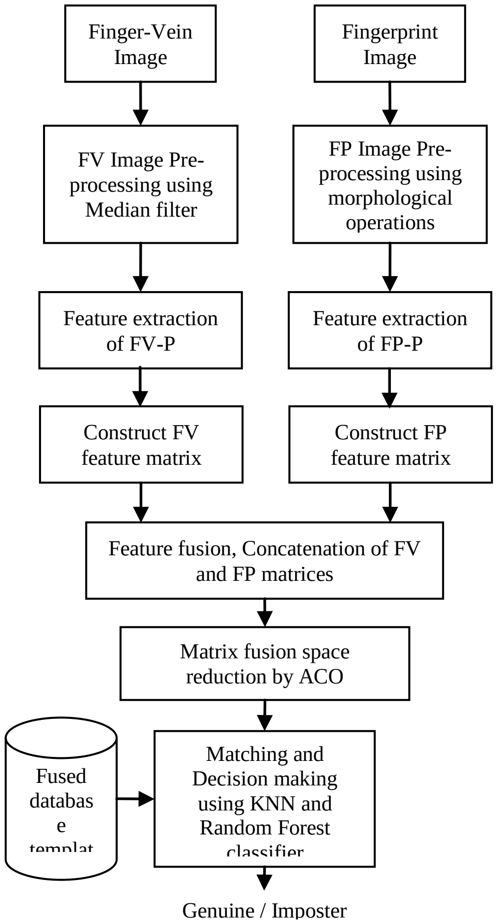

Figure 1: Flow diagram for proposed approach

Here FV is finger-vein, FP is fingerprint and FV-P, FP-P are feature vectors for finger-vein and fingerprint respectively.

Steps for the methodology:

- **Step 1:** It performs pre-processing of finger-vein and fingerprint images using median filter and morphological operations respectively.
- **Step 2:** The process will extract the features of both traits by using Gabor filter and wavelet moments, and generate feature vectors.
- **Step 3:** Selected features vectors will be fused by using concatenation.
- **Step 4:** Feature subset selection on fused feature vector will be performed by using ACO-based feature selection method.
- **Step 5:** The KNN and Random forest classifiers are used to generate match score and decision will be taken as genuine or imposter.
- **Step 6:** Performance of proposed multimodel biometric system on evaluation parameters; equal error rate and accuracy.

B. Pseudo Code for the Feature Level Fusion

For each individual image do

P_FV=preprocess(FV_image);P_FP=preprocess (FP_image);

FV=feature_extraction(P_FV);FP=feature_extraction(P_FP);

fusion_features = concatenation (new_FV, new_FP);
feature_matrix = construct (fusion-features);
Endfor
feature_select = ACO (fusion_feature);
result_Randomforest=Randomforest_classification(feature_select);
result_KNN = KNN_distance(feature_select);
compare(result_ Randomforest, result_KNN);

C. Pre-Processing

The pre-processing of finger-vein image is accomplished by the median filter whereas the morphological operations are used for the pre-processing of the fingerprint image.

1) Median Filter

The principle of the Median filter is often defined in the case of a discrete image, whose practical implementation is direct. From the discrete concepts, it is possible to give a continuous version, which will be adapted to the theoretical study of some of its properties [11].
Figure 2 depicts process of median filter.

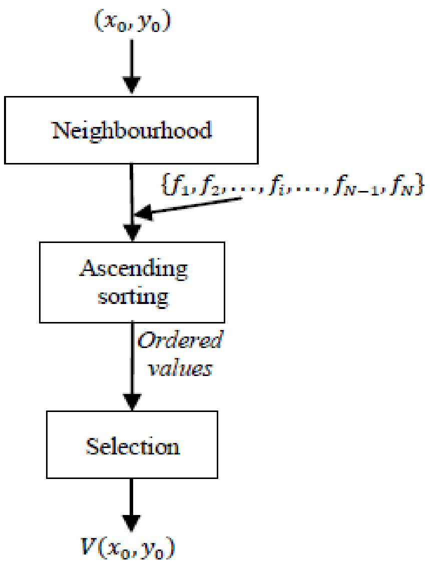

Figure 2: Median filter

Consider a discrete image F characterized by a gray level $f(x, y)$. Let $V(x_0, y_0)$ be the neighborhood associated with the coordinate point (x_0, y_0); it is assumed that this neighborhood has N coordinate pixels $(x_0 - u, y_0 - v)$ with odd N.
Let $\{f_1, f_2, \ldots, f_i, \ldots, f_{N-1}, f_N\}$ the gray levels associated with the N pixels of $V(x_0, y_0)$.
The median filtering first proceeds by sorting the gray level values of the neighborhood followed by a selection of the middle element of the sorting.
Sorting is done in ascending order generally. It leads to the ordered set of gray values of the neighborhood of $f(x_0, y_0)$.
Since the ordered elements are denoted by f_i, the ascending sort is characterized by:

$$f_q < f_2 < \cdots < f_{\frac{N+1}{2}} < \cdots < f_{N-1} < f_N \quad (1)$$

The middle element of the neighborhood is $f_{\frac{N+1}{2}}$. Its property is to be preceded by $\frac{N-1}{2}$ lower values and followed by as many higher values.

The filtering consists of replacing $f(x_0, y_0)$ by the median value of the neighborhood $f_{\frac{N+1}{2}}$ [11].

2) Morphological Operations

Mathematical morphology processes images with the help of previously chosen special shapes, which are generally smaller than the image and are called the structural element [12], which acts as an operator on an image to produce a result. The shape, size and orientation of the structural element are chosen based on prior knowledge taking into account the relevant geometric structures that are present in the image and the objective pursued with the morphological operation implemented [12]. Each structure element requires the definition of a point of origin (or reference) for its application as a morphological operator. This allows the structure element to be related in a particular way to the pixels of the image.
Dilation: It is also called expansion, filling, or growth, produces a thickening effect on the edges of the object. This algorithm is used to increase the contour of the objects and to join the discontinuous lines of these, produced by some filtration, mathematically the binary dilation is defined as:

$$A \oplus B = \{c \in E^{N|\,C=a+} b \ for\ all\ a \in A\ and\ b \in B\} \quad (2)$$

Erosion: Erosion is the dual function of expansion, but it is not the reverse, i.e. if erosion is done and then a dilation, the resulting image will not be equal to the actual image, mathematically erosion represented as:

$$A \ominus B = \{x \in E^N | x + b \in A\ for\ all\ b \in B\} \quad (3)$$

D. Feature Extraction by Gabor Filter

This paper is particularly interested in the method of Gabor filters. They owe their name to Dennis Gabor (1900-1979), the English physicist who invented holography. These filters, whose operation is close to human visual processing, have the advantage of being parameterizable in terms of frequency and orientation. We implemented them and applied them to various images.
Gabor's function is the association of a Gaussian curve and an oriented sinusoid (see Figure 3).

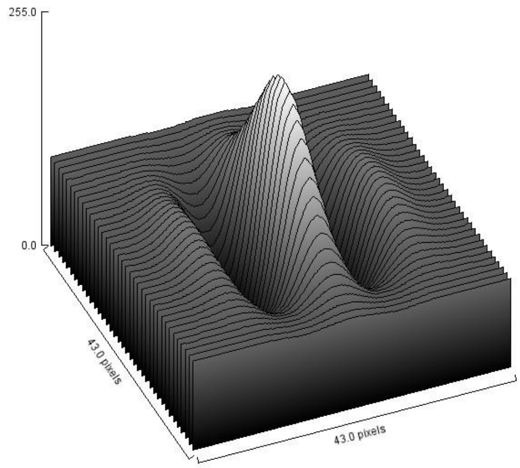

Figure 3: Three-dimensional representation of the standardized Gabor function between values 0 and 255[12].

In image processing, we are working in the space domain in two dimension, which allows us to write the function of Gabor as follows:

$$G(x,y,\theta,f) = e^{-\frac{1}{2}\left(\frac{x_\theta^2}{\sigma_x^2}+\frac{y_\theta^2}{\sigma_y^2}\right)} \cos(2\pi f x_\theta) \quad (4)$$

Where, $x_\theta = x\cos\theta + y\sin\theta$ and
$y_\theta = y\cos\theta - x\sin\theta$
Where, θ is the orientation of the sinusoid, f its frequency and, σ_x (respectivelyσ_y) the standard deviation of the Gaussian along the ordinate.
Applying this function to a convolution mask, we define a convolution filter that we call Gabor filter (see Figure 4).

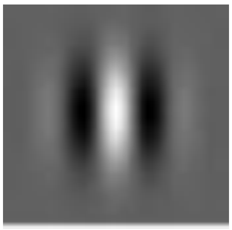

Figure 4: Mask of the Gabor filter with radius 21 pixels for $\theta = 0$, $f = \frac{\sqrt{2}}{10}$ and $\sigma_x = \sigma_y = 7$[12].

The application of a Gabor filter g mask M of radius r to an image I of width m and height n, is therefore summarized in the following formula:

$$g(I) = J = M * I \quad (5)$$

Where J is a matrix of dimension $m \times n$ and for $i,j \in 1,2,3 \dots,\ r \le i < m - r$ and $r \le j < n - r$

$$J_{i,j} = \sum_{k=-r}^{r}\sum_{l=-r}^{r} M_{k,l} \times I_{(i-k),(j-l)} = \sum_{k=-r}^{r}\sum_{l=-r}^{r} G(k,l,\theta,f) \times I_{(i-k),(j-l)} \quad (6)$$

As we will see, Gabor's filters make it possible to isolate the contours of an image of orientation perpendicular to θ and corresponding to a certain thickness, which depends on f.

E. Feature Extraction by Wavelet Moments

The reconciliation (A) represented by the input image itself with reduced size which is known as approximation coefficient. However the detailed coefficients are referred as; and diagonal (d), horizontal (h) and vertical (v). The outcome of first level DWT on an image M is represented as [13]:

$$M = M_a^1 + \{M_h^1 + M_v^1 + M_d^1\} \quad (7)$$

Dimension reduction of input data is achieved using N-level DWT. After 4-level DWT, the image M is expressed as:

$$M = M_a^4 + \sum_{i=1}^{4}\{\{M_h^i + M_v^i + M_d^i\}\} \quad (8)$$

After 2-level DWT, input image having the dimension $m \times n$ is estimated to $\frac{m}{2} \times \frac{n}{2}$.
Fourier transform is applied to get frequency domain image, expressed as:

$$DWT_{x(n)} = \begin{cases} dd_{j,k} = \sum img(n) hh^*{}_s(n - 2^s r) \\ ap_{j,k} = \sum img(n) ll^*{}_s(n - 2^s r) \end{cases} \quad (9)$$

Where, $ap_{j,k}$ are the approximate coefficients and $dd_{j,k}$ is detailed coefficients. Functions $ll(n)$ and $hh(n)$ are low pass and high pass filters respectively. Parameters r and s are wavelet translation and scale factors respectively.
Standard deviation and mean is given by:

Mean

The mean of a random variable vector A, Having N scalar observations, is expressed as:

$$\mu_{mn} = \frac{1}{N}\sum_{i,j=1}^{N} ap_{ij} \quad (10)$$

Where the approximate coefficient is symbolized by ap_{ij}.

Standard Deviation

$$\sigma_{mn} = \sqrt{\frac{\sum_{i=1}^{m}\sum_{j=1}^{n}(|I_{mn}(i,j)| - \mu_{mn})^2}{N-1}} \quad (11)$$

Where $I_{mn}(i,j)$ shows the values detected by the sample items.
With the use of the mean and standard deviation, the wavelet moments is expressed as:

$$f_g = (\mu_{00}, \sigma_{00}, \mu_{01}, \sigma_{01} \dots \dots . \mu_{45}, \sigma_{45}) \quad (12)$$

F. Feature Subset Selection using Ant Colony Optimization Technique

Ant colony optimization simulates the ants behaviour that accrued pheromones onto the routes in which they move when searching for food. The pheromone level accrued on a particular route increases with the number of ants going through the path. To find the shorter route to a food source, ants utilize pheromones to cooperate and communicate with each other. By using a fusion of pheromone information and heuristic, ants choose the next node to visit [14].
In our research work an n-sized feature set is given from feature extraction phase, the FS problem is to select a minimal subset of size $(m < n)$, and maintaining accuracy in representing the original feature.
Following are the steps for feature subset selection approach:

Step 1: Ants generation and initialization of pheromones

- Define ants population
- Set pheromone trial intensity of any feature
- Regulate maximum iterations permitted.

Step 2: Ant Foraging and assessment

- An ant assigned a feature arbitrarily; it will tour all features and form a complete solution.
- The assessment parameter is Mean Square Error (MSE) of a classifier. If an ant is not capable to reduce the MSE in five consecutive steps, it will end its work and terminate.

Step 3: Assessment of particular subsets

- Sorting of subsets corresponding to length and performance of the classifier, thereafter, choose the best subset.
- Exit, if no. of iterations > allowed maximum iteration, else continue.

Step 4: Updating Pheromone

- Reduce pheromone collection of nodes, thereafter the quantity of pheromone are deposited by all ants on the chart, lastly, permitted the best ant to store further pheromone.

Step 5: New ant generation

- New ants are generated and old ants are deleted.

Step 6: Go to **Step 2** and continue.

- If I indicate number of iterations, a is the total no. of ants, n is the total no. of original features, the time complexity of this method is (Ian).

The abovementioned steps are clearly shown in Figure 5.

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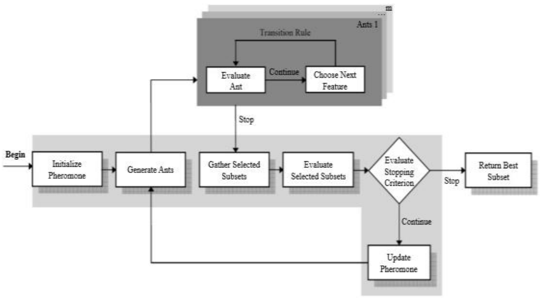

Figure 5: Feature subset selection using ant colony optimization [15]

G. *Classification Algorithms*

1) *KNN-Classifier*

The notations for KNN classifier method are as follows:
D indicates a file of N cases, each of which is characterized by n predictor variables, $X_1, \dots, X_n$ and a variable to predict, class C.
The N cases are denoted by:

$$(X_1, X_1), \dots, (X_N, C_N) \tag{13}$$

Where,
$X_i = (x_{i,1} \dots x_{i,n})$ for all $i = 1, \dots, N$
$C_i \in (c^1, \dots, c^m)$ for all $i = 1, \dots, N$
$c^1, \dots, c^m$ denote the possible m values of the variable class C.

Pseudo-code for the KNN classifier

Start
Entry: $D = \{(X_1, C_1), \dots, (X_N, C_N)\}$
$X = (x_1, \dots, x_n)$ *new case to classify*
FOR any object already classified (x_i, c_i)
calculate $d_i = d\ (X_i, X)$
Sort $d_i (i = 1, \dots, N)$ *in ascending order*
Stay with the K *cases already classified* D_X^K *closer to* X
Assign X *the most frequent class in* D_X^K
End

2) *Random Forest Classifier*

The random forest technique modifies the Bagging method applied here to trees by adding a de-correlation criterion between these trees. The idea behind this method is to reduce the correlation without increasing the variance too much. The principle is to randomly choose a subset of variables that will be considered at each level of choice of the best node of the tree.

Consider a training set $S = \{(x_1, y_1), \dots, (x_m, y_m)\}$, a has the number of attributes of the examples of X. Also consider S_t a bootstrap containing m instances obtained by resampling with replacement of S. Let $\{h_1, \dots h_t\}$ be set of T decision trees. Each tree h_t is built from S_t. For each node of the tree, the partitioning attribute is chosen by considering a number $f (f < a)$ of randomly selected attributes (among the attributes a). To classify a new instance x, the random forest classifier performs a uniformly weighted majority vote of classifiers in that set for instance x. The algorithm illustrates this principle [16].

Algorithm*:*

Input: $S = \{(x_1, y_1), \dots, (x_m, y_m)\}$, *the training set.*
Input: T, *the number of decision trees in the random forest.*
For $t = 1, \dots, T$ *do*

1. *Generate a Bootstrap sample* S_t *of size m from S*
2. *Create a decision tree* h_t *from* S_t *by recursively repeating for each node of the tree the following steps:*
   a. *Randomly select* f *attributes among a attributes.*
   b. *Choose the partitioning attribute among* f
   c. *Partition the node into two child nodes*

End for
Output: H, *the random forest classifier*

IV. SIMULATION AND RESULTS

MATLAB (2015a) based simulation scenario has been developed and simulation results are based on equal error rate and accuracy.

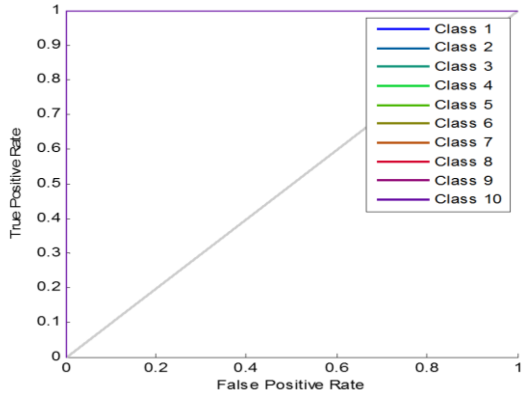

Figure 6: ROC of random forest

Figure 6 show the graphical scenario for fusion of features. Space reduction of features is accomplished by ant colony optimization. The Gabor and Wavelet Moment features are reduced from 182 features to 150 by the ACO. The overall space reduction percentage is 17.58% for fingerprint and finger-vein images. It was found that the ACO based fusion approach outperforms the basic fusion with a number of (75*2) which means that the ACO based fusion uses only 75 attributes to achieve better accuracy.

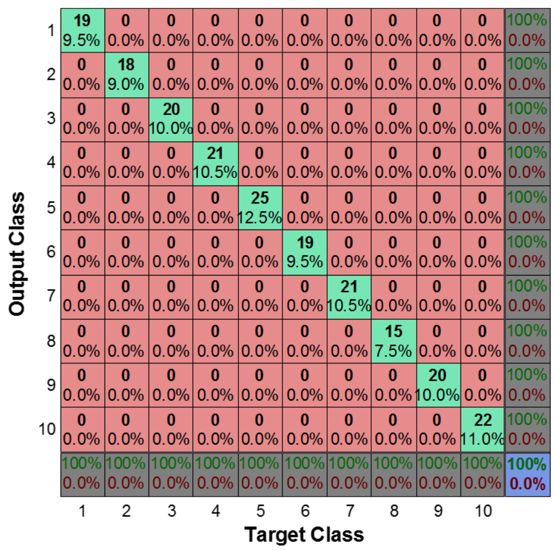

Figure 7: Confusion matrix plot for Random forest classifier

Table 1: Comparative analysis

Method	Equal Error Rate (EER)	Accuracy
Multimodal system by SVM [10]	0.31%	99.69%
Multimodal system by KNN [10]	0.94%	99.06%
Proposed method using KNN classifier	0.04	99.60%
Proposed method using Random forest classifier	0%	100%

V. CONCLUSION

In this paper, a combination finger-vein and fingerprint recognition approaches form a multimodal biometric recognition system. Median filter and morphological operations are used to for pre-processing of the input image. The feature extraction is accomplished by wavelet moments and Gabor filter. Ant colony optimization is used for subset selection of extracted features. Classification is done by using the KNN and random forest classifiers. It was found that the random forest classifier outperforms the KNN on the basis of equal error rate and accuracy. The maximum accuracy of this approach is 100%.

REFERENCE

1. Unar, J. A., Woo Chaw Seng, and Almas Abbasi. "A review of biometric technology along with trends and prospects." Pattern recognition 47, no. 8 (2014): 2673-2688.
2. S. Cole, Suspect Identities: A History of Fingerprinting and Criminal Identification. Harvard University Press, 2001.
3. Z. Mc Mahon, Biometrics: History, Indiana University, Indiana University Computer Science Department, 24 January 2005.
4. John Daugman: "How iris recognition works". IEEE Transactions on Circuits and Systems for Video Technology 14(1), January 2004, pp. 21–30.
5. Jain, A. K.; Ross, Arun; Prabhakar, Salil (January 2004), "An introduction to biometric recognition", IEEE Transactions on Circuits and Systems for Video Technology 14th (1): 4–20.
6. D. Maltoni, D. Maio, A. K. Jain, and S. Prabhakar, Handbook of Fingerprint Recognition, Springer, NY, 2003.
7. Ching-Liang Su: Hand Shape Recognition by Hand Shape Scaling, Weight Magnifying and Finger Geometry Comparison. MIRAGE 2007: 516-524.
8. Ralph Gross. “Face Databases” In S.Li and A.Jain, (ed). Handbook of Face Recognition. pp. 1-22 Springer-Verlag, 2005.
9. Karnan, Marcus, Muthuramalingam Akila, and Nishara Krishnaraj. "Biometric personal authentication using keystroke dynamics: A review." *Applied soft computing* 11, no. 2 (2011): 1565-1573.
10. Khellat-kihel, R. Abrishambaf, J.L. Montriro, and M. Benyettou, “Multimodel fusion of the finger vein, fingerprint and the finger-knuckle-print using Kernel Fisher analysis”, Applied Soft Computing, 42, pp. 439-447, 2016.
11. Sezan, M. Ibrahim, and Reginald L. Lagendijk, eds. Motion analysis and image sequence processing. Vol. 220. Springer Science & Business Media, 2012.
12. Shih, F. “Image processing and mathematical morphology”. Boca Raton: CRC press, 2009.
13. Bhattacharjee, Anwesha, Monisha Saggi, Ramya Balasubramaniam, Akash Tayal, and Ashwini Kumar. "Decision theory based multimodal biometric authentication system using wavelet transform." In 2009 International Conference on Machine Learning and Cybernetics, vol. 4, pp. 2336-2342. IEEE, 2009.
14. Latha, L., and S. Thangasamy. "On improving the Performance of Multimodal biometric authentication through Ant colony optimization." WSEAS Transactions on Information Science and Application, Issue 12, Volume 8, 2011.
15. Aghdam, Mehdi Hosseinzadeh, Jafar Tanha, Ahmad Reza Naghsh-Nilchi, and Mohammad Ehsan Basiri. "Combination of ant colony optimization and Bayesian classification for feature selection in a bioinformatics dataset." Journal of Computer Science & Systems Bio.
16. Breiman, L. Manual on setting up, using, and understanding random forests v3, Statistics Department University of California Berkeley, CA, USA, 2002.

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