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IMAGE & SIGNAL PROCESSING

A Multimodal Authentication for Biometric Recognition System using Intelligent Hybrid Fusion Techniques

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Abstract
Biometric Recognition and Authentication is used in many applications for the secured identification of the persons. Several Researches has been carried out to strengthen the security algorithms through which the identification can be done in secured manner. With this objective, a new algorithm called Hybrid Adaptive Fusion(HAF) has been proposed which works on the principle of hybrid fusion of two feature inputs such as Hand geometry and iris of the users. As mentioned, the proposed algorithm uses the novel and hybrid fusion of feature extraction along with the accurate machine learning classifier. Effective Linear Binary Patterns (ELBP) and Scale Invariant Fourier Transform (SIFT) are stored in the databases for the further verification. The features stored are fed into the Extreme Learning machines for the detection of the verified users. This algorithm has been tested with the CASIA Image Datasets and with the different classifiers such as Neural Networks, Baiyes Networks. The proposed algorithm with ELM has better accuracy of 98.5% when compared with the other machine learning algorithms.

Keywords HAF-ELM · SIFT · CASIA · LBP · Biometric Recognition · Extreme Learning machines

Introduction

Biometric authentication and recognition has taken the new branch of exploration in adoption of newer techniques in terms of security, higher accuracy and high speed. Many techniques has been proposed one such technique is Fusion of the different Images. The different images such as palm, finger print, hand geometry, iris, Finger knuckle has been taken as the inputs and these inputs are fused in order to increase the high security mechanisms [1, 2].

With the advent of machine learning along with the fusion of the images are implemented for the better image authentication system. Machine learning Algorithms plays an important role for the classification of the images from the forgery images. The design and the implementation of machine learning algorithm plays an important role in the authentication system. Several Algorithms such as the Artificial neural networks, Support vector machines, Random forests, and Naïve Bayes classifier algorithms were used for the authentication systems. But the improvisation in the machine learning algorithm for the better accuracy of detection, remains to be real challenge among the researchers. In this research, we have proposed integration of the hybrid feature extraction along with powerful extreme learning machines.

Also the paper proposes the novel scheme of fusion known as HAF(Hybrid and Adaptive Fusion) with the two different feature extraction techniques such as Effective linear binary patterns(ELBP) and SIFT(Scale Invariant Fourier Transforms) for the better accuracy and high speed. The biometric recognition can be used for any smarter authentication systems in banking, medical and defense systems. The paper organized as follows as: A) Related works B) Proposed Systems with Block Diagram

This article is part of the Topical Collection on *Image & Signal Processing*

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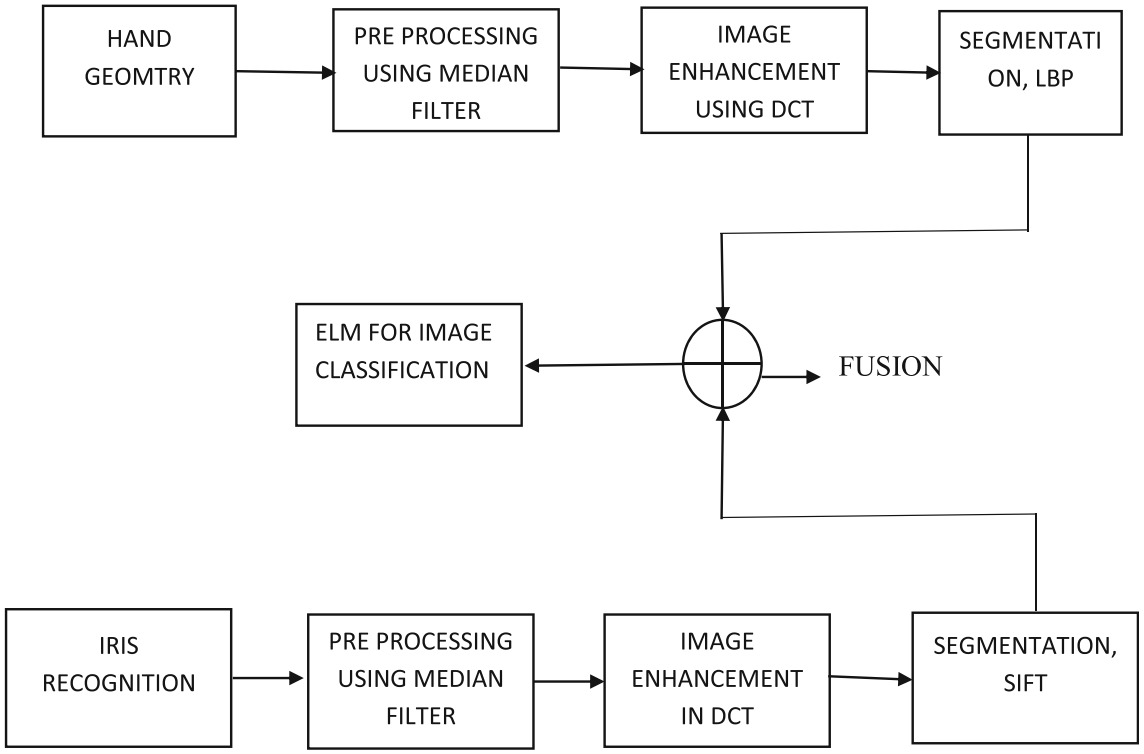


Fig. 1 Proposed System

C) Overall System Designs D) Results and Comparison E)Conclusion.

Related Works

Ola M. Aly nadHoda M. Onsi, proposed a multimodal biometric system which depends upon combining iris recognition, finger print recognition. With the help of normalization of min-max, the fusion procedure is carried out. By analyzing linear discrimination, the significance of the finger joints are taken out. But the feature extraction at fusion level has two problems mainly to notice and they are incompatibility among various feature vectors and choosing the classifier is very difficult for joint feature vectors [3].

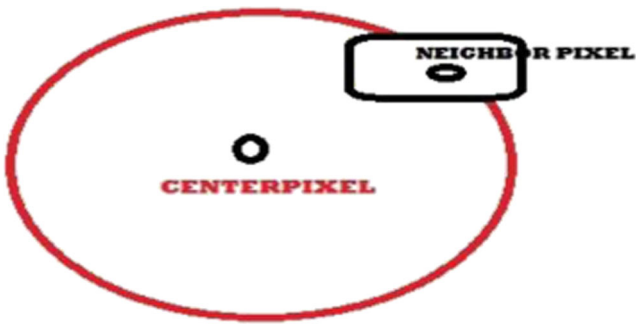


Fig. 2 Linear Binary Patterns-Mechanism of taking the center Pixels with respective to the Neighborhood Pixels

Anixi Antonakoudi, Anastasis Kounoudes and Zenonas Theodosiou proposed a technique in which principle of face recognition, thumb recognition, speech recognition techniques are combined and analysis carried out. Where more than thirty data set considered. For every recognition, there are five data sets are considered. All the recognition scheme is merged and selection based on the majority of recognition and results in strong classifier which offers greater rate of acceptance and rejection for false selection. However, the proposed system required long period of time for the data collection and it is highly time-consuming process hence it significantly requires test subjects with their biometric traits [4].

A Anil K. Jain, Arun Ross, and Salil Prabhakar, proposed a approach which based on three recognition such as face recognition, gait recognition and palm print obtained with contact. In this paper, researchers proposed algorithm for selecting for associate region. Training phase is executed for every recognition in associate region based on geometric data excited by projection pursuit method and later low dimensional space projections are found. The primary issues of the biometric system is it cannot give assurance of privacy because it may give

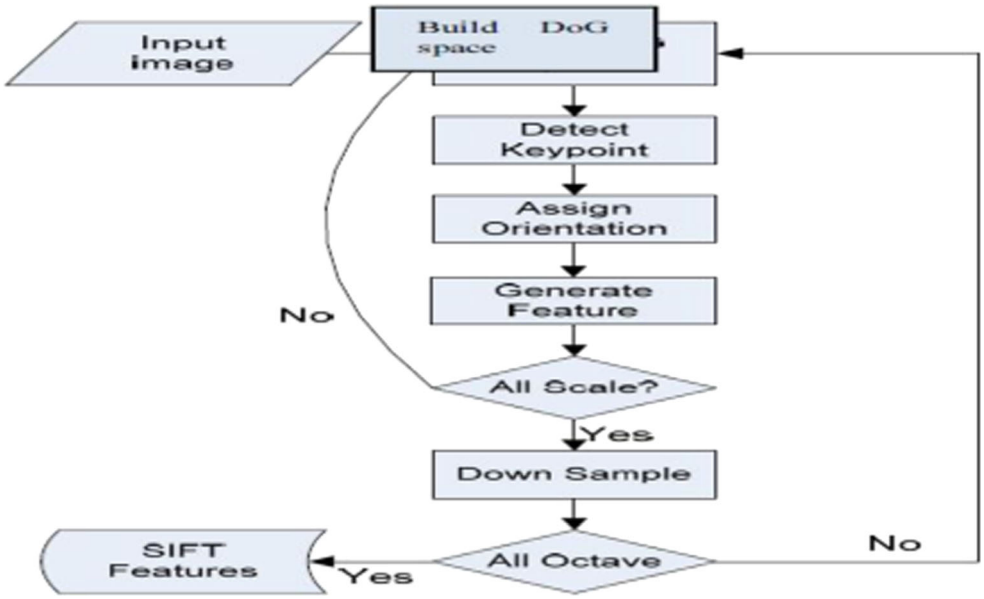


Fig. 3 Scale Invariant Fourier Transforms-its Working Mechanisms

background information of individual also in wrong situation [5].

El-Alfy, E. S., & Bin Makhashen, G. M proposed a method in which image will be extracted easily with client hand gesture. The procedure carried out on the edge of the left hand finger and right hand finger thumb. To execute classification, totally ten traits are taken out. Where, Classification process done with help of back propagation learning algorithm. In the result there is an impact in the system performance due to redundant attributes of hand geometry and there is also a negative impact because of two finger width features in considered data base [6].

Das, P., & Meshram, S presented novel technique in facial recognition in which, datas are interpreted from sub regions of whole desired face. Statistical shape modeling used for 1segmentation.Researcher developed Radial basis function Neural network classifier. This technique has a disadvantage of very low enrolling rate [7].

Duraipandi, C., Pratap, A., &Uthariaraj, R presented a novel technique where five types of data of cattle taken for analysis and did comparison with existing techniques. In this proposed work, GLCM matrix which indicates high intensity of pixel of the image. Here performance analyzed on five number of modules with hundred iteration result in dynamic cattle recognition. But the computational time and noise has to be reduced further for the robust features [8] (Fig. 1).

Table 1 comparison of HAF –Type-A and Type B

TYPE	IMAGE SIZE	FEATURES	FEATURES	FUSION
HAF-TYPE-A	256 × 256	122	128	250
HAF-TYPE-B	256x256	118	110	219

Proposed Method

The proposed HAF algorithm has given as follows:

Mechanism Of Working HAF

HAF works on the Bi-Modal Fusion techniques in which the hand geometry's features has been taken as the LBP and other IRIS Images has been taken as the SIFT has the major techniques for the features.

1. Input Image:

The Input Image of the Hand Geometry and IRIS has been taken from the CASIA databases version 4.0 .the sample images.

Table 2 Parameters details for feature detection

S.No	Parameters details	Parameters used
01	No of Hidden Neurons	45
02	Activation variables	TAN
03	Input Variables	Bio-metric+Iris Fused −01
04	Output Variables	01

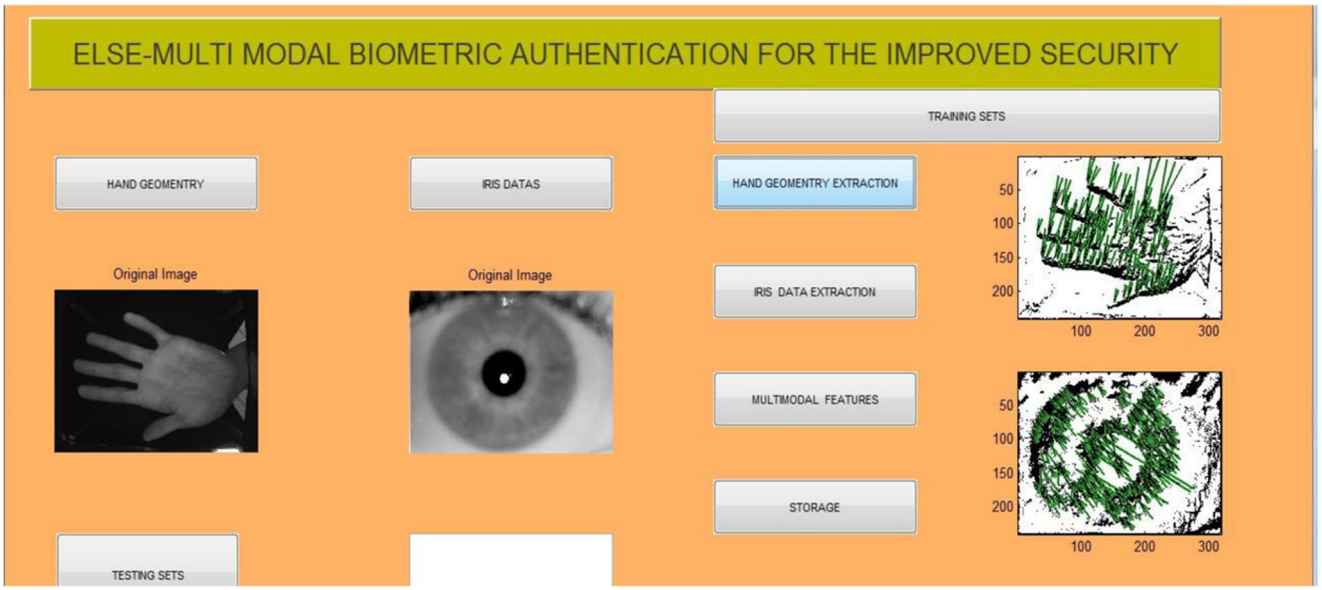


Fig. 4 The System GUI developed for the HAF Fusion of Images

2. Preprocessing of the Images:

As the next step for the both the images are preprocessed using the median filters for the removal of the noises and smoothening in the images collected from the databases.

3. Image Enhancement using DCT:

The pre processed images are fed to the Discrete Curvelet Transforms for better clarity of the Images for the efficient processing.

4. Hybrid Adaptive Features Mechanism:

HAF follows the two important categories of the feature extraction which are given as follows as

1. Effective linear Binary Patterns(ELBP)
2. Scale Invariant Fourier Transforms(SIFT)

Effective Linear Binary Pattern(ELBP): The tem LBP deals with the unique feature extractions based on the textures. Where divide and conquer approach followed.

As the next step, the desired pixel is compared with adjacent eight pixels and if desired pixel value is larger than neighbor value, it is treated as 0, else treated as 1. It yields eight bit binary value as shown in fig. 2.

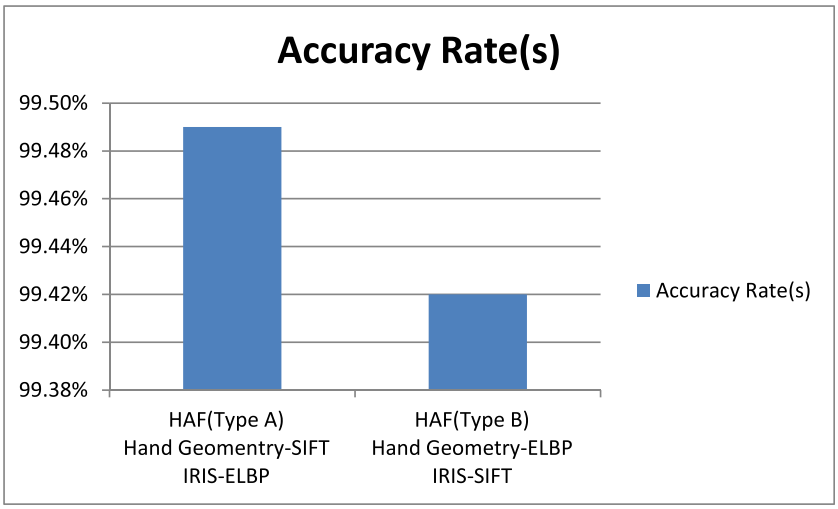
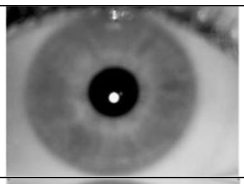
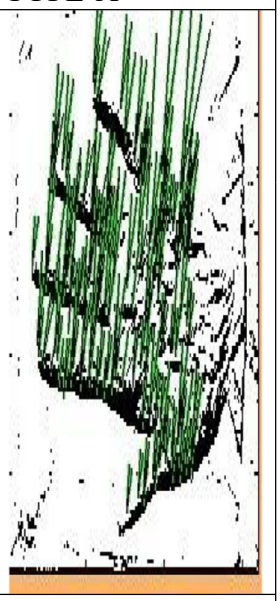
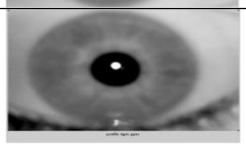
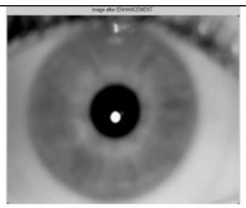
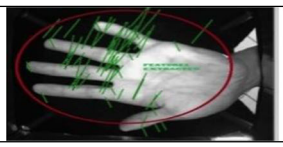
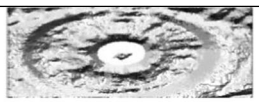


Fig. 5 The Graphical Representation of performance of the HAF(Type-A) & Type-B

Table 3 HAF TYPE-A OUTPUT ANALYSIS

Stages of processing	Test Image-Hand Geometry	Test Image-Iris Images	Fused Image in TYPE-A
1.Input Image			
2.Image Filtering Process			
3.Image Enhancement Process			
4.Feature Extraction Process			

The histogram is computed among the cell and occurrence of pixel value. Then the histogram looks like a 32-dimensional vectors of feature for the image size 256 × 256.

SIFT method

Another feature extraction method used in the proposed system is SIFT(Scale Invariant Fourier transforms) which is used to detect the features of the image. SIFT keypoints are extracted from the images and uses the principle of measuring the Euclidian distance between the keypoints for matching**.** In this method, four stage method is adopted for the extraction of the feature from the image size of 256 × 256 which are given as follows (Fig. 3).

The proposed algorithm consists four different stages which are listed as

1. Scale Space Extreme detection
2. Keypoint Localistaion
3. Orientation assignment
4. Key point descriptor

Scale space functions are used for the identification of the position of similar object from the various dimension.

Where scale space function is expressed as:

$$S(x, y, \sigma) = G(x, y, \sigma) * I(x, y)$$

Right side of the above equation indicates convolution of variable scale Gaussian G(x, y, σ) and input image I(x, y).

The next stage is keypoint localization which are used for elimination of more points to form the précised new points.

Next step is Orientation Assignment. The main objective of this step is to allocate orientation for the key points which are depends on properties of the image.

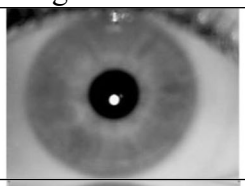
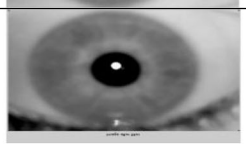
Final step is Key point Descriptor which are aims to generate the major keypoint descriptors. There are sixteen histograms, arranged as 4 × 4 matrix and are 8 bins oriented. 128 elements are formulated after the keypoint descriptors.

Finally all the feature vectors extracted and concatenated to form the Single dimensional features .

Fusion Mechanisms:

In the Final stage, HAF takes into the two important types, the first one is Type –A and another one is Type-B .

Table 4 HAF TYPE-B OUTPUT ANALYSIS

Stages of processing	Test Image-Hand Geometry	Test Image-Iris Images	Fused Image in TYPE-B
1.Input Image			
2.Image Filtering Process			
3.Image Enhancement Process			
4.Feature Extraction Process			

In the Type-A, Fusion take place when the hand geometry ‘s features are extracted by SIFT and the IRIS Images as ELBP. In the type-B reverse operations are performed. These kind of operations are used in the HAF for the better accuracy in which the selection of the types will be done manually or automatically. This is illustrated in Table 1.

Table 5 The accuracy rate measurement when HAF is categorized into two types

SL.NO	Algorithms	Test Images	Hit Ratio	Miss Ratio	Accuracy Rate
01	HAF(Type A) Hand Geomentry-SIFT IRIS-ELBP	700	695	006	99.49%
02	HAF(Type B) Hand Geometry-ELBP IRIS-SIFT	700	693	007	99.42%

Extreme Learning Machines

Extreme Learning Machines(ELM) for single-hidden layer feed forward neural networks is presented [9, 10]. In ELM, N number of neurons considered in hidden layer Also, it is not necessary to vary or adjust this layer. The output of neural network is expressed as

Table 6 The response time of proposed algorithm with existing system [1]

SL.NO	Algorithms	Test Images	Response Time [Training]	Difference in Time
01	HAF (Type A)	Hand Geomentry+ IRIS	35.5 s	5.5 s
02	HAF (Type B)			
03	Existing System	Hand Geomentry+ IRIS	40s	

Table 7 The recognition time of proposed algorithm with existing system [1]

SN	Algorithms	Test Images	Recognition Time [Training]	Difference in Time
01	HAF (Type A)	Hand Geometry+ IRIS	47.8 s	2.2 s
02	HAF (Type B)			
03	Existing System	Hand Geometry+ IRIS	50s	

$$f_L(x) = \sum_{i=1}^{N} \gamma_i h_i(x) = h(x)\gamma$$

In the above equation, x represents input with size of d, $\gamma = [\gamma_1 \ldots \gamma_N]^T$ represents output weights of hidden layer. Where computation of $h_i(x)$ is done by group of non linear functions which are suitable to the necessity of approximation proofs [10].

$$h_i(x) = G(a_i, b_i, x)$$

Let N represent function of neuron, a_i the weights of the hidden layer and b_i represents the bias parameters. Finally N function which expressed as Sigmoid which represented as

$$N(a_i, b_i, x) = \frac{1}{1 + \exp(-(a_i.x + b_i))}$$

Apart from this sigmoid function, more number of functions such as fourier transform, Gaussian process are there [10].

When iteration starts, the values of γ are produced indiscriminately and intermediate weights are used to reduce the inaccuracy. With ELM, solution is provided for the system which exhibit linearity and system described as $H = \gamma T$ where H represents output matrix of hidden layer and T represents desired training matrix. At many situations, count of hidden layer nodes is less than count of training data. Therefore solution to the system H is given below

$$\gamma = H^+ T$$

where H+ represents Moore-Penrose generalized inverse. This work is implemented with MATLAB based methodologies for effective testing of the algorithms.

In the Extreme learning machines, features are normalized and the following parameters are taken for the detection of features as shown in Table 2.

Overall System Developed

The overall system developed using the MATLAB GUIDE tool for the testing and making the tools for the designs (Fig. 4).

The Table 3 and 4 describes about the different stages of the proposed authentication system. In this methodology, Extreme learning machines are used for the fusion of the images and also for the classification of the images. The two types of the features were extracted and were named as type-A and type-B for obtaining the better accuracy.

Results and Comparison

The proposed algorithms has been evaluated in terms of accuracy and computation time. The above two parameters are used for the detection of performance of the system and response time of the proposed system for the given inputs.

Biometric Accuracy

The system incubates the two number of inputs such as the hand geometry and Iris images. The accuracy ratio can be found as

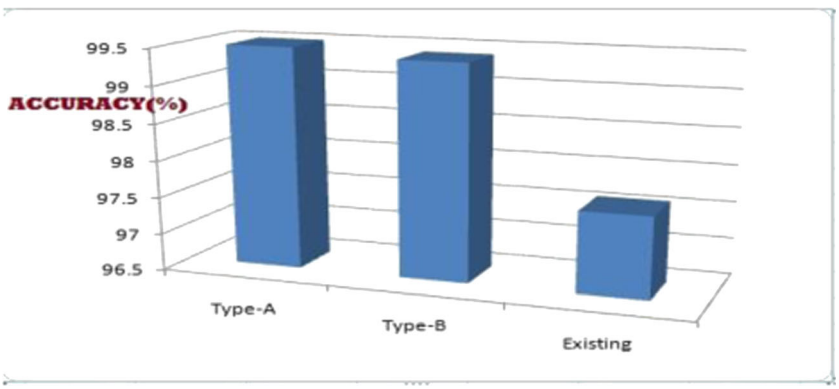


Fig. 6 The Graphical Representation of comparative performance of the HAF(Type-A) & (Type-B) with the existing system [1]

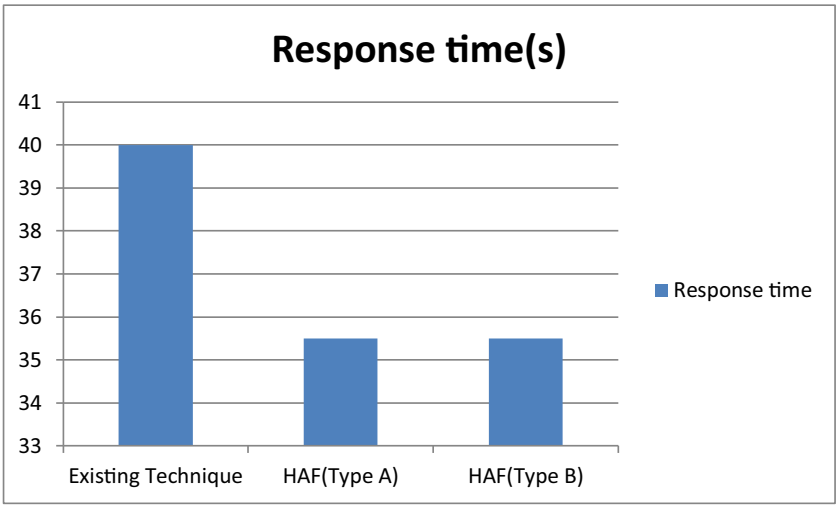


Fig. 7 The training response time for the Image Fusion using the HAF(A&B) with that of existing systems

$$\text{Accuracy ratio} : (\text{No of Hit Ratio})/(\text{Total Number of Trials})*100 \quad (1)$$

The proposed system is taken the input image from CASIA which is the hand geometry Image database, own data and trained up to 1000 images. Accuracy rate is calculated based on number of corrected (hit ratio) with respective to the total number of images t which is taken from a standard databases. The evaluation of presented method is been calculated based on the two categories of shown in Table (1) and Fig.5 shows the graphical representation of the performance of the systems. Table 5 shows accuracy measurement.

Comparison

The obtained results has been compared with the existing systems [1] which is depicted in table 6 & 7.

The computation analysis such as accuracy rate, training response time & recognition time are evaluated for the Input datasets and comparison obtained through existing systems [1] (Fig.6, 7 and 8).

Also the HAF is tested with the Extreme learning machines and compared with the other algorithms such as the Neural networks and Naïve Bayes Classifier which are illustrated below in Table 8. The CASIA datasets were used for evaluation in which the 70% were utilized for training and 30% were used for testing.

From the above Table 8, HAF-ELM provides the better accuracy when integrated with Extreme Learning machines. Also accuracy is more when compared with other intelligent. Hence Extreme Learning machines are more suitable for the verification of the fused image features.

Conclusion

The proposed algorithm HAF(Type-A &Type-B) has been designed and compared with the existing algorithms. It proves

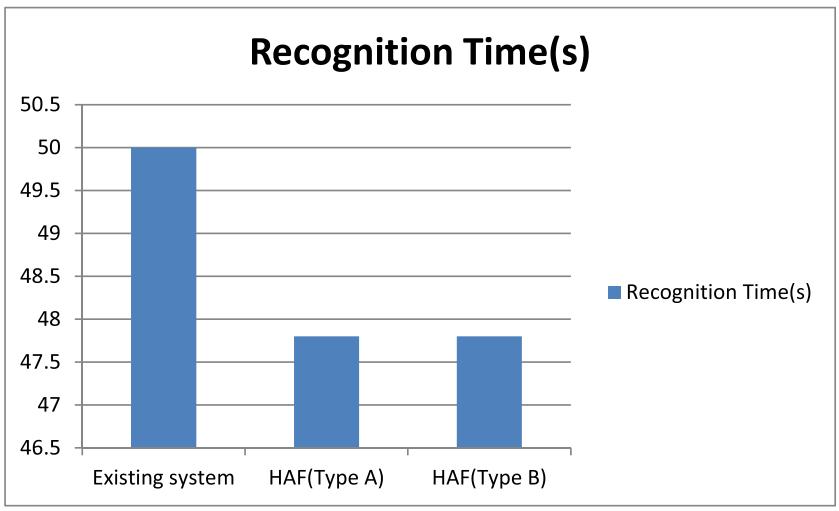


Fig. 8 Comparative charts of the recognition time for Fusion using the HAF(A&B) with that of existing systems [1]

Table 8 The Comparative Analysis for HAF in combination of different algorithms

Sl.no	Testing Parameters	Algorithm Used		
		HAF-ELM	HAF-NN	HAF-NB
01	Accuracy (Training)	98.5%	95.4%	96.4%
02	False alarm ratio	2.5%	4.5%	4.0%
03	Accuracy (Testing)	98.5%	95.4%	96.4%

to be high edge over the existing systems with high speed and accuracy. In this paper, the algorithm presented has been tested with the CASIA datasets and the approach of combining the two different features extraction methods proves to be more efficient compared with the other algorithms. This kind of the algorithms finds its application in defense, medical, etc. Integration of Extreme Learning machines along with the HAF makes the system more accurate in which it can be used for the various applications. Further the proposed system can be enhanced with the more intelligent algorithms such as Deep learning algorithms and also with the advent of IoT (Internet of things), the proposed system provides the way to the multi-modal authentication systems.

Compliance with Ethical Standards

Conflict of Interest S. Prabu declares that he has no conflict of interest. M. Lakshmanan declares that he has no conflict of interest. V. Noor Mohammed declares that he has no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

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