A Novel Approach Based on Nature Inspired Intelligence for Face Feature Extraction and Recognition

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***Abstract*— Feature Extraction and Feature Selection are the most important steps that can affect the performance of a Face Recognition system. In this research we have used a meta-heuristic approach to solve the problem of face recognition. The proposed algorithm is applied to features extracted using discrete wavelets and feature selection is done using Artificial Bee Colony (ABC) optimization where evolution is driven by fitness function defined in terms of correlation value for pattern recognition. Finally Ant Colony optimization (ACO) technique is used for face recognition by measuring the distances between the selected features. Experimental results show that the algorithm was found to generate encouraging recognition results with the minimal set of selected features.**

Keywords—Face Recognition; ABC; ACO; Feature Selection

I. INTRODUCTION

Face Recognition is performed by humans routinely and effortlessly. Humans hold a magnificent expertise in recognizing faces. We aim at developing systems with same kind of adroitness. Face recognition has been a popular research topic in recent years [1-2]. It covers a wide spectrum of application areas including biometric authentication in security systems [3], image and film processing, human-computer interaction, multimedia management and video surveillance [4].

A. Feature Extraction

To recognize a human face, some special features such as eyes, nose, mouth, hair and chin along with shape of face need to be extracted. Hence feature information is imperative for face recognition. In literature [5-7] we observe various feature extraction approaches but four approaches are extensively used viz. Discrete Fourier Transformation [8], Discrete Cosine Transformation [9], Eigenvectors (Principal Component Analysis) [10-11], and Discrete Wavelet Transformation [12].

B. Feature Selection

The detected components, positions and distances through feature extraction are used to process the features of the face. Hence selection of appropriate feature becomes an acute task. Feature selection is a process of finding a subset of features, from the original set of features forming patterns in a given data set, optimal according to the given goal of processing [13-15]. We accomplish the task of face recognition in 3 stages. The first stage is Feature Extraction, second is Feature Selection and the final stage is Face Recognition based on the selected features. In this paper Feature Selection has been done using the concept of Artificial Bee Colony Optimization based on the normalized correlation coefficient used for pattern matching [16].

The paper has five sections. Section 2, following the Introduction provides a basic overview of the techniques. In section 3 deals with the proposed algorithm. Results are discussed in section 4 and finally the paper is concluded in section 5, with the future scope of our work.

II. AN OVERVIEW OF TECHNOLOGIES USED

A. Discrete Wavelet Transformation

The wavelet transform is a proficient tool for texture discrimination. It is a linear operation that decomposes a signal into components that appear at different scales [17]. Wavelet Transforms are based on small waves called wavelets of varying frequency and limited duration which makes the transformation and compression and analysis of an image easy as compared to Discrete Fourier Transformation and Discrete Cosine Transformation. This transform is based on the convolution of the signal with a dilated filter [18]. The Wavelets may be classified into two classes namely Orthogonal and bi-orthogonal. The coefficients of orthogonal filters are real numbers and filters are of same length but are not symmetric. In case of bi-orthogonal wavelet filters, the low pass and high pass filters do not have the same length. The low pass filter is always symmetric while high pass filter could be either symmetric or anti-symmetric, and the coefficients of filters are either real numbers or integers [19]. The combination of low pass and high pass filters helps in detection of features from an image. Study in [20] shows the use of bi-orthogonal wavelets filters for image feature extraction.

B. Nature Inspired Intelligence

Behavior of variety of the interesting insect or animal in nature has always been captivating the researchers. Biologists and computer scientists in the field of "artificial life" modeled biological swarms to understand how social animals interact, achieve goals, and evolve [21]. Swarm Intelligence is an innovative distributed intelligent paradigm for solving optimization problems inspired from the biological examples by swarming, flocking and herding phenomena in vertebrates [22]. The problem solving techniques of insects, birds or animals are adopted by researchers for optimizing solutions to their problems. Swarm Optimization incorporates swarming behaviors observed in flocks of birds, schools of fish, swarms of bees, ant colonies and even human social behavior, from which the idea of nature inspired intelligence is emerged.

1) Artificial Bee Colony

ABC was originally presented by Dervis Karaboga [23] from the inspiration of collective behavior of honey bees with better solutions to optimization problems as compared with genetic algorithms (GA), differential evolution (DE), and particle swarm optimization (PSO) [24]. In the nature honeybees explore the locality of their hive in search of better nectar sources [25]. There are 3 types of bees depending on their work, employed bees, onlooker bees and the scout bees. The employed bees first leave the hive and search in particular direction for sources of pollen and nectar. After finding a suitable nectar source they go back to the hive and share their information with onlooker bees. Information exchange is done by the bees at the dancing area in the hive. Bees exchange information (the locations, quantity and quality of existing sources of pollen, nectar) about the food sources by intensity, duration and direction of the bee during 'waggle dance'. The onlooker bee after watching the dances chooses the most profitable source and follows one of the employed bees to the discovered source of food. Upon arrival to the food source, the foraging bee takes a load of nectar and returns to the hive. Scout bees investigate new areas with possible food sources randomly without any prior information [26]. The described process continues constantly, while the bees from a hive collect nectar.

2) Ant Colony Optimization

Ants are the social creatures that work in groups to find food. In ACO, proposed by Margo Dorigo [27], a number of artificial ants build solutions to optimization problems and exchange information on the quality of these solutions through a communication scheme that is evocative of the one adopted by real ants.

Ant colony optimization is an iterative algorithm. In each iteration, a number of ants travel from their nests in search of food. Each of them builds a solution by walking from vertex to vertex on the graph with the constraint of not visiting any vertex that it has already visited in its walk. At each step of the solution construction, an ant selects the following vertex to be visited according to a mechanism that is biased by the pheromone. At the end of an iteration, on the basis of the quality of the solutions constructed by the ants, the pheromone values are modified in order to bias ants in future iterations to construct solutions similar to the best ones previously constructed.

III. PROPOSED ALOGORITHM

The algorithm consists of two parts: in the first part artificial bee colony optimization technique is used to select features from the images and matched with the database images, in second part ant colony optimization technique is used for the face recognition based on the selected features in the first part. Fig. 1 shows the steps followed in the proposed algorithm.

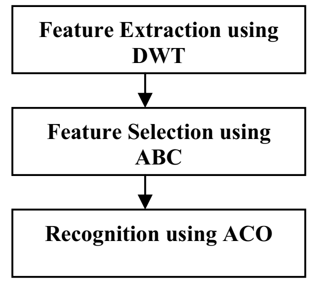

Fig. 1. Steps for Face Recognition in the proposed algorithm

A. Feature Selection Using ABC

Before selecting feature using ABC technique we assume that:

1. Bees are represented by the pixels of the image
2. Each feature extracted is a food source
3. Number of food sources = number of employed bees (one bee employed on each food source)
4. Number of onlookers = Ol
5. Number of scout bees = 1
6. Hive = collection of information and dancing area of bees (the image available)

In this paper we have taken image (face) to be recognized with white background and normal lightening as input and Steps Involved in Feature Selection ABC Algorithm are:

Step-1(Initialization): Initialize the population of solutions/features (food sources). Place an employed bee on each food source.

Step-2(Quality Assessment of Food Source): Evaluate the quality of food sources using normalized correlation coefficient c(x,y) [16]:

$$c(x,y) = \frac{\sum_s \sum_t [f(s,t) - \bar{f}(s,t)][w(x+s,y+t) - \bar{w}]}{\{\sum_s \sum_t [f(s,t) - \bar{f}(s,t)]^2 \sum_s \sum_t [w(x+s,y+t) - \bar{w}]^2\}^{\frac{1}{2}}} \tag{1}$$

where:

$c(x,y)$ → Correlation coefficient range [-1,1]

w → Filter mask of size mXn (template)

$\bar{w}$ → Average value of mask.

$\bar{f}$ → Average value of *f* in region co-incident with *w*.

f → Image in database.

Correlation is referred to as template (w) matching.

Step-3(Greedy selection by Onlooker Bees): For all Food Sources calculate the probability of values of each solution (food source) using equation (2) and onlooker bee will select food source with maximum P_i value [23] and follow the employed bee to the selected food source:

where P_i,

$$P_i = \frac{c_i}{\sum_{n=1}^{N} c_n} \tag{2}$$

Also,

$i \rightarrow \{1,2,...,N\}$ where N=total number of food sources

$P_i \rightarrow$ Probability of i^{th} food source

$c_n \rightarrow$ Correlation value

Repeat Step-2 for each onlooker bee and compute the probability (correlation value) for each onlooker bee.

Step-4(Selection of feature): Using equation (3) find the average of correlation value obtained by each onlooker bee for a particular food source. If average of correlation value obtained is equal or greater than zero then select the feature and goto Step 6 else goto Step 5.

Where, average of correlation is:

$$\frac{\sum_{i=1}^{Ol} c_i}{Ol} \geq 0 \tag{3}$$

where,

$Ol \rightarrow$ Number of onlookers

$c \rightarrow$ Correlation value

Step-5(Re-Selection): Produce a candidate food position from the old one in memory which might have been abandoned while feature extraction using the expression (4) [23]:

$$v_{ij} = x_{ij} + \varphi_{ij}(x_{ij} - x_{kj}) \tag{4}$$

Where,

k = {1, 2, . . . , N} and j= {1, 2, . . . ,D} are randomly chosen indexes. Although k is determined randomly, it has to be different from i. x_{ij} and x_{kj} are random pixel values. φ_{ij} is a random number between [-1, 1].

After each candidate source position v_{ij} is produced and then evaluated by the artificial bee, its performance is compared with that of its old one. If the new food source has equal or better nectar than the old source, it is replaced with the new one in the memory. Otherwise, the old one is retained in the memory. In other words, a greedy selection mechanism is employed as the selection operation between the old and the candidate one.

Step-6(Fitness Calculation): Calculate the fitness (f_{it}) [23] of the solution attained using equation (6), based on the average correlation attained for selected features using equation (5):

$$f = \frac{\sum_{i=1}^{Ns} c_i}{Ns} \tag{5}$$

where,

Ns $\rightarrow$ number of selected features

$$fit = \begin{cases} \frac{1}{1+f}, & f \geq 0.8 \\ 1 + abs(f), & f < 0.8 \end{cases} \tag{6}$$

If the value of fit ≤1, then continue with Face Recognition else, EXIT (image do not match)

B. Recognition Using ACO

Before feature selection using ACO technique we assume that:

1. Nodes/Food-source represents features that have been selected.
2. Ants are represented by the pixels of the image.

Steps Involved in Recognition using ACO Algorithm are:

Step-1(Initialization): Determine the population of ants (equal to the number of features) and set the intensity of pheromone trial associated with any path among features. (i.e. read the distances among features in the given image and determine the distance threshold) and also Determine maximum number of iterations allowed (number of nodes and paths to be traversed)

Step-2 (Generation of Ants): Place one ant on each selected feature. Any ant (Ai, i=1:N) is randomly assigned to a feature it should visit all features and build solutions completely.

Step-3 (Evaluation Criterion): In this step the evaluation criterion is the Euclidean distance among the features and the comparison of distances with the distances in the original image. If the distances among the features meet the requirements with not more than a deviation of 40% for all the paths then EXIT.

Step-4 (Check the stopping criterion): If ants have visited all the features/nodes and paths (reached the maximum number of iterations allowed) then EXIT otherwise continue.

Step-5 (Pheromone updating): For features that are selected in Step-3 pheromone intensity is updated (mark the path as verified and node as visited.

IV. Results and Discussion

A. Data Set

To analyze the efficiency of the algorithm we have taken two images of size 200X150 that are stored in the database and the expert defines three meaningful features, each of the images is matched with all the test images.

TABLE I. DATABASE AND THE TEST IMAGES

S. No.	*Database Images*	*Test Images*		
		a	*b*	*c*
1.				
2.				

B. Implementation and Discussion

The features from all the test images are extracted using DWT. Table 2 shows the extracted features that will be matched with the features defined in the database images using feature selection algorithm.

TABLE II. FEATURES EXTRACTED FROM TEST IMAGES

Features Extracted from Test Images		
a	**b**	**c**
		

As per the ABC Feature selection algorithm, the correlation values of each feature extracted from the test images is calculated with respect to the pre-defined features in the database images.

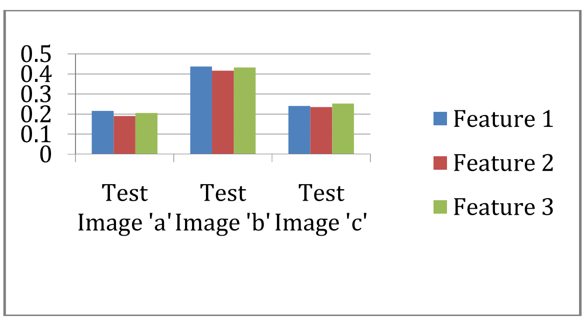

Fig. 2. The correlation values of features in test images matching with features of Database Image-1.

Next, the correlation values of the 10 onlooker bees for the featured matched in previous step are calculated.

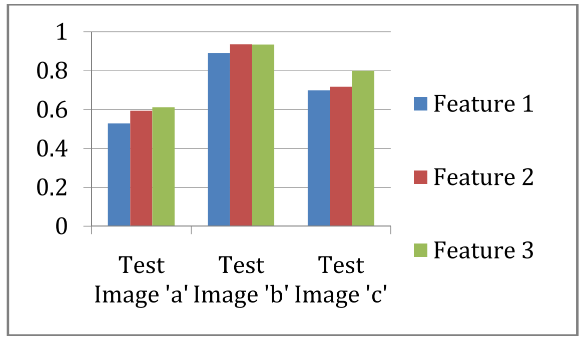

Fig. 3. The average correlation values of 10 onlookers for each feature selected from test images for Database Image-1.

Next, the fitness of each solution is evaluated.

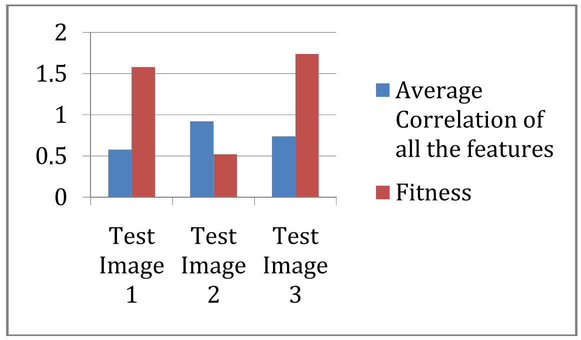

Fig. 4. Fitness values for each solution with the average correlation values.

As seen the test image ‘a’ and ‘c’ have the fitness>1 hence they are rejected and image ‘b’ is selected for face recognition. In the next step Face recognition algorithm using ACO is implemented on test image ‘b’ and Table 3 shows the results obtained:

TABLE III. THE FINAL PHEROMONE TRIAL VALUES OBTAINED FOR THE FEATURES IN TEST IMAGE SELECTED FROM ABC ALGORITHM

		Distance between corresponding features		
		F1 – F2	*F2 – F3*	*F1 – F3*
DBImage		45.0000	49.2443	51.4782
Test Image ‘b’	***Ant1***	40.0125	36.7696	30.4138
	Ant2	38.2099	60.4401	51.0000
	Ant3	48.5077	59.4811	71.1126
Pheromone Value		3	3	2

As pheromone values for all the features is greater than or equal to 2, the test image ‘b’ is selected. Similar results were observed for the Database Image-2(shown in Table 1), the test image ‘a’ was found matching.

V. Conclusion and Future Scope

A novel face recognition technique is proposed using the swarm intelligence techniques. Facial feature selection has been enhanced by adopting the problem solving technique ABC, that iteratively matches the features with the image in the database and face recognition is finally completed using the ACO by comparing the distances among the features of test image to the ones stored in the database. Experimental results show that the proposed system can be used for the Face Recognition efficiently. Our future work will concentrate on side face recognition and face recognition in images taken in poor lightening conditions. The proposed algorithm is likely to give much better results if feature extraction techniques are enhanced.

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