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Investigational study on discovery of face in versatile circumstances through Genetic and Ant Colony Optimization Algorithm

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ABSTRACT

In this paper a novel face identification technique, ACOG algorithm has been proposed which is a hybrid of ACO (Ant Colony Optimization) algorithm and GA (Genetic algorithm). The ACO processes and extracts the features of the input image over which several pre-processing steps are done to enhance the chances of feature extraction. The extracted features are given as input to GA which detects the face features and compares the features with the existing face database.

Introduction

With the increasing necessity of computing in this technological civilization, computer vision has gained much importance. The goal of computer vision is the ability of computers is to achieve visual recognition ability comparable to that of human. Among many recognition subjects, face recognition has drawn considerable interest and attention from many researchers for the last twenty years because of its possible applications, such as in the areas of surveillance, secure trading terminals, Closed Circuit Television (CCTV) control, user authentication, Human Computer Interface(HCI), Humanoid robot. Many approaches have been proposed over these years for efficient face recognition.

Among numerous computing techniques soft computing techniques have been gaining much importance in the recent years because of its flexible and robust nature. In this paper we propose a novel face identification system that employs two different soft computing techniques for efficient face recognition and identification.

Face identification system

The proposed face identification system can be divided in to two major entities. They are the image pre-processing system [1,2] followed by face identification system. The image pre-processing system is used for image enhancement clipping and filtering the given image for easy and efficient feature extraction in the later stage of face identification. Further the edges of the image are detected by using ACO algorithm. Then using GA the detected edges are compared with the available database of images and the best fitting image is identified. A special advantage of the proposed technique is that there is no extra learning process included here, only by saving the face information of the person and appending the person's name in the learned database completes the recognizing process. The image shown in figure 1 shows the basic work flow of the FIS(face identification system) discussed in this work.

Face Image Acquisition

Before we start to do face identification or even image enhancement, we have to acquire the raw data of image for further processing. Any image data is an array of pixel values which can be represented as a matrix, where the rows and column are the image dimension itself.

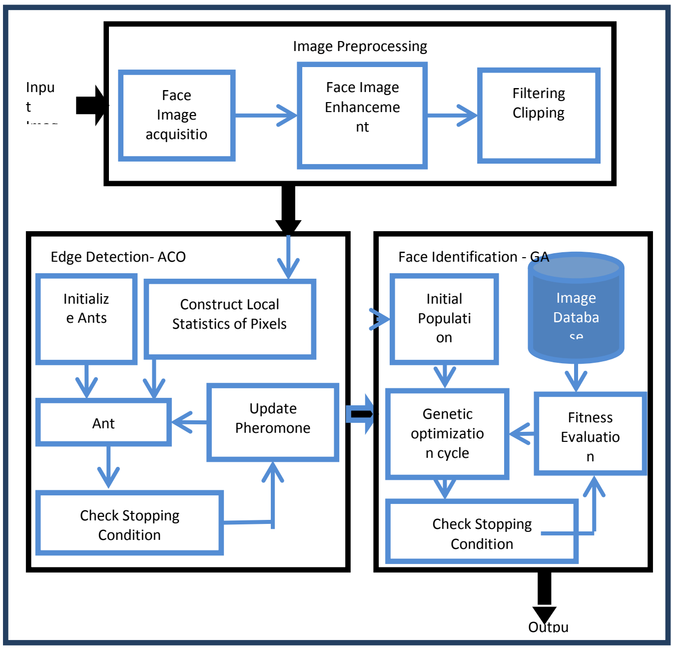

Figure 1. Basic work flow of FIS

The number of bits used to represent the pixel values of component images determines the bit depth of an RGB image. An RGB color image is an MxNx3 array of triplet data corresponding to the red, green and blue components of an RGB image. M and N are the number of pixels corresponding to the length and width of the image. The range of values is [0,255] or [0, 65535] for RGB images of class unit 8 or unit 16 respectively. The number of possible colors in an RGB image is $(2b)^3$, where b is the number of bits in each component image. For 8-bit case, the number is 16,777,216 colors. The RGB is converted into gray scale images for further image processing. Thesenumerical data are used for image enhancement in the former and face detection and identification in the later stage.

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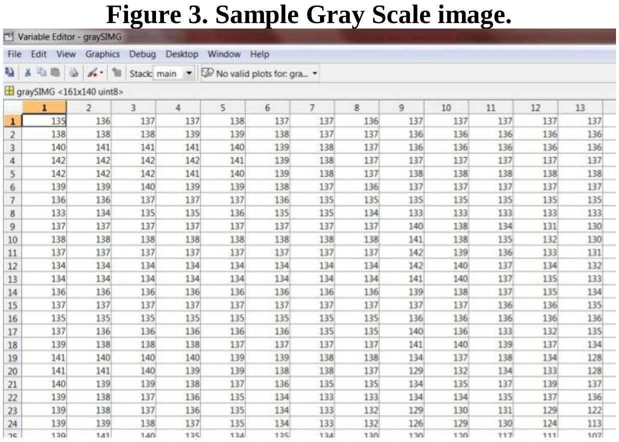
The image in figure 2 shows the sample image used in this paper.

Figure 2. Sample RGB image.

The sample RGB image is converted to gray scale image for better image processing. The edges of the image can be detected efficiently in gray scale mode than in RGB mode[1,3,20]. Hence the image is converted to gray scale mode before further enhancement techniques are employed. Figure 3 shows the gray scale image of the RGB image shown in figure 2. Figure 4 shows the sample numerical data of the image shown in figure 2.

Figure 3. Sample Gray Scale image.



Variable Editor - graySIMG

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	1	2	3	4	5	6	7	8	9	10	11	12	13
1	135	136	137	137	138	137	137	136	137	137	137	137	137
2	138	138	138	139	139	138	137	137	136	136	136	136	136
3	140	141	141	141	140	139	138	137	136	136	136	136	136
4	142	142	142	142	141	139	138	137	137	137	137	137	137
5	142	142	142	141	140	139	138	137	138	138	138	138	138
6	139	139	140	139	139	138	137	136	137	137	137	137	137
7	136	136	137	137	137	136	135	135	135	135	135	135	135
8	133	134	135	135	136	135	135	134	133	133	133	133	133
9	137	137	137	137	137	137	137	137	140	138	134	131	130
10	138	138	138	138	138	138	138	138	141	138	135	132	130
11	137	137	137	137	137	137	137	137	142	139	136	133	131
12	134	134	134	134	134	134	134	134	142	140	137	134	132
13	134	134	134	134	134	134	134	134	141	140	137	135	133
14	136	136	136	136	136	136	136	136	139	138	137	135	134
15	137	137	137	137	137	137	137	137	137	137	136	136	135
16	135	135	135	135	135	135	135	135	136	136	136	136	136
17	137	136	136	136	136	136	135	135	140	136	133	132	135
18	139	138	138	138	137	137	137	137	141	140	139	137	134
19	141	140	140	140	139	139	138	138	134	137	138	134	128
20	141	141	140	139	139	138	138	137	129	132	134	133	128
21	140	139	139	138	137	136	135	135	134	135	137	139	137
22	139	138	137	136	135	134	133	133	134	134	135	137	136
23	139	138	137	136	135	134	133	132	129	130	131	129	122
24	139	139	138	137	135	134	133	132	126	129	130	124	113

Figure 4. Sample numerical data of Gray Scale image in 'Figure 2'.

Image Pre-Processing

Image pre-processing is done for enhancing the features of the input image for efficient image recognition. Image enhancement is done in a series of steps by employing different filtering techniques. Those steps are discussed as follows.

Histogram equalization and Normalization

After the image is converted togray scale the image data is enhanced by equalizing the histogram of the image, histogram equalization is done to enhance the contrast of the image. After enhancing the contrast of the image, it is normalized so that the possibility of edge detection is improved.

The histogram equalized image is shown in figure 4. It is clearly seen that the contrast of the image is enhanced when the histogram of the image is equalized[19,21]. The histogram of the image is shown in figure 5.

Figure 4. Histogram equalized image.

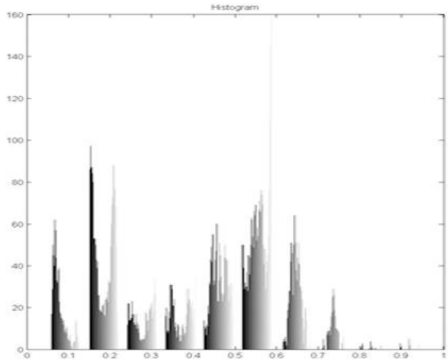

Figure 5. Histogram of Figure 4

Figure 6. Normalized image after histogram equalization

Filtering and Clipping

The input image is prone to contain noise which should be removed. There are different types of noise those affect the image [1,13,17]. They are Gaussian, Salt and Pepper, Shot, uniform, film grain and Non-Isotropic noise which would damage the image data. To efficiently remove this noise *prewitt filtering* technique is used. The filtered image is shown in figure 7.

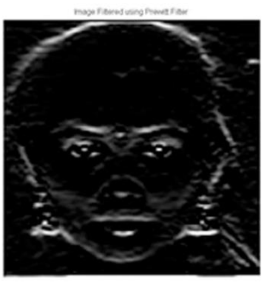

Figure 7. Image shown in Figure 6 Filtered using Prewitt filtering technique

This is a non-linear digital filter often used to remove noise in an image. Noise reduction helps us to improve the results in the later stages of the face identification. Prewitt filter is used exclusively for noise removal, because it removes noise from the image without damaging the edges of the image. To improve both the image and the quality of filtering, the filtered image is dilated and eroded. Dilating and Eroding the image is called as morphological operations. The dilated and eroded image is shown in figure 8.

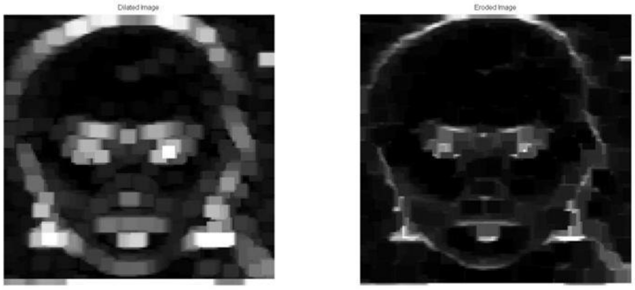

Figure 8. (i) Dilated Image (ii) Eroded Image

After the morphological operations, the image is clipped to obtain the necessary data that is required for further processing of the input image. The noise reduced image is shown in figure 9.

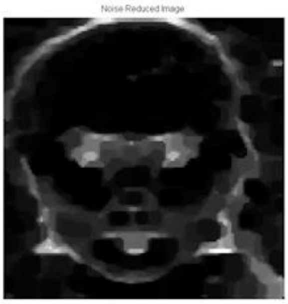

Figure 9. Noise reduced image

With these three sections described above the image pre-processing is over and the image is ready to be identified. Thus the image is presented as input to the next stages of the FIS.

FIS (Face Identification System)

Our vision system works by identifying the edges of the scenes we see. Our brain automatically identifies the edges and clusters the edges of objects together. Thus our brain lets us to identify different objects easily by identifying edges and clustering them automatically. Thus for implementing image recognition for an artificial intelligent system the edges of the image should be identified. To identify the edges, we have used ACO *(Ant Colony Optimization)*. ACO is an evolutionary optimization technique which is based on the act of ants foraging for food. The identified edges are cross checked by GA *(Genetic Algorithm)* with a database of images, which identifies the availability of a particular image in the database. Thus the face is first detected and then identified from the database of available images.

Edge Detection

As discussed above, ACO is used for detecting edges of the image. In this algorithm the nodes represent features, with the edges between them denoting the choice of the next feature [4,5,15]. The search for the optimal feature subset is then an ant traversal through the graph where a minimum number of nodes are visited that satisfies the traversal stopping criterion. The formula used in this technique is shown below in (1).

$$p_{ij}^{k}(t) = \begin{cases} \dfrac{[\tau_{ij}(t)]^{\alpha}.[\eta_{ij}]^{\beta}}{\sum_{l \in J_i^k}[\tau_{il}(t)]^{\alpha}.[\eta_{il}]^{\beta}} & \text{if } j \in J_i^k \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

Where, k is the number of ants; η_{ij} is the heuristic desirability of choosing feature j; j is the set of neighbour nodes of node i which has not yet been visited by the ant k; τ is the amount of virtual pheromone on edge (i,j). The pheromone is updated during each iteration by the formula shown in formula 2 and 3 [6,7].

$$\tau_{ij}(t+1) = (1-\rho).\tau_{ij}(t) + \rho\Delta\tau_{ij}(t) \quad (2)$$

$$\Delta\tau_{ij}(t) = \sum_{k=1}^{n}(\gamma'(S^k)/|S^k|) \quad (3)$$

Where ρ is the pheromone evaporation coefficient. By employing this technique the edges of the image is identified. The use of ACO in our system is shown in figure 10.

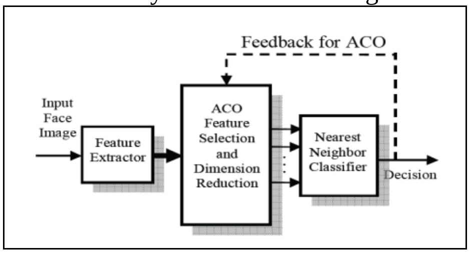

Figure 10. Use of ACO in FIS

The edges are identified by employing different modes, thus we get a diversified types of edges of the same image, which improves the output of FIS [7,8,12]. The edges detected by using different modes are shown in figure 11.

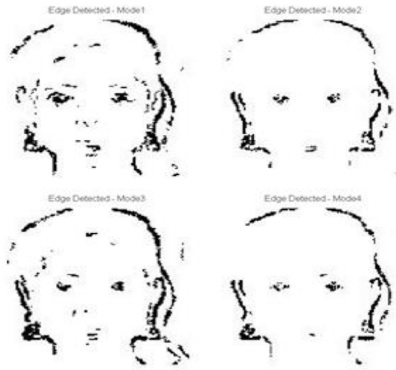

Figure 11. Edges detected by ACO by employing different modes.

Face detection

In this work Genetic Algorithm is used for face identification [8,9,15]. To get started with GA the initial population should be identified first. The initial population in our work is the image itself. The pixels of an image are the actual data of the image[8,10,14]. The pixels of an image are encoded to form the chromosomes. 'N' number of such chromosomes constitutes a generation. Encoding the chromosome of a 10x10 pixel image is shown in the following images.

136	137	137	138	137	137	136	137	137	137
138	138	139	139	138	137	137	136	136	136
141	141	141	140	139	138	137	136	136	136
142	142	142	141	139	138	137	137	137	137
142	142	141	140	139	138	137	138	138	138
139	140	139	139	138	137	136	137	137	137
136	137	137	137	136	135	135	135	135	135
134	135	135	136	135	135	134	133	133	133
137	137	137	137	137	137	137	140	138	134
138	138	138	138	138	138	138	141	138	135

Figure 12. Pixels of a 10x10 image.

136	137	137	138	137	137	136	137	137	137
138	138	139	139	138	137	137	136	136	136
141	141	141	140	139	138	137	136	136	136
142	142	142	141	139	138	137	137	137	137
142	142	141	140	139	138	137	138	138	138
139	140	139	139	138	137	136	137	137	137
136	137	137	137	136	135	135	135	135	135
134	135	135	136	135	135	134	133	133	133
137	137	137	137	137	137	137	140	138	134
138	138	138	138	138	138	138	141	138	135

Gen e1	Gen e2	Gen e3	Gen e4	Gen e5	Gen e6	Gen e7	Gen e8	Gen e9	Gene 10

Figure 12. Representation of encoding pixels of an image to a chromosome

As shown in the representation, each gene is a vector of 10 pixel data. The chromosome consists of 10 genes, where each gene is a vector of 10 data. Thus all data of the image has been packed in to a chromosome. After generating the initial population, the GA routine is performed to find the best matching image from the database [7,9,10]. To do this efficiently the pixel data of the edge detected image is encoded as the chromosome and compared with the database [11,12,13]. The GA routine is as follows; selection, crossover, mutation and evaluation using fitness function.

The selection technique used in our work is roulette wheel selection technique. In this technique each chromosome is given a slice of the wheel. The area of the slice is based on the fitness value of the chromosome, obviously which indicates that the highly fit chromosomes occupy a wide area compared with the chromosomes with less fitness value.

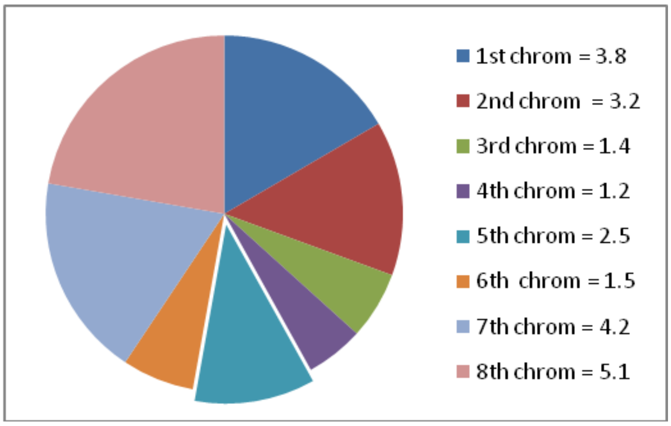

Figure 13. Roulette wheel, representing fitness of a chromosome.

To select the chromosome, a random number is generated between 0 and 100. The selected the chromosome is the one whose segment spans the random number.

The selected chromosomes are subjected to crossover, so the features are exchanged which paves way to generate the best fit chromosomes and hence find the best matching chromosome. In this method we have employed multipoint crossover method. The multipoint crossover method is represented pictorially in the figure 14.

Figure 14. Representation multipoint crossover method.

The length of chromosome represented in the figure 14 is 45. The legends P1, P2 are the parent chromosomes 1 and 2 selected for crossover and C1, C2 are the children generated after the crossover process. It can be seen that the children have the properties of their parents mixed which may result as a good member with good fitness value or a bad member with low fitness value.

The mutation is done to implement the evolutionary strategy in GA [10,13]. To implement mutation a random bit is selected and the value is altered by replacing it with any random value that falls within the range of all possible values for a gene. In our work since we use grayscale images. The range is between 0 and 255. The mutation will either result in a good chromosome or a bad chromosome.

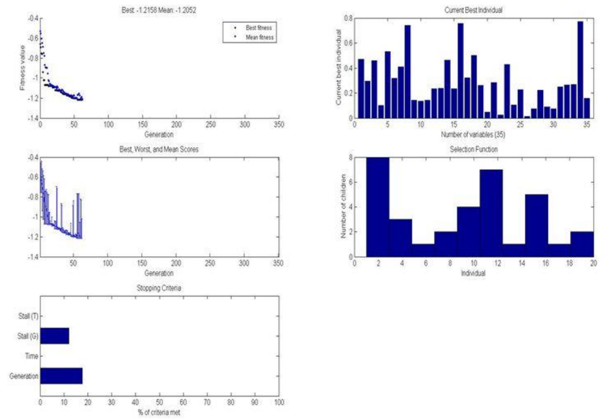

Figure 15. Shows the overall output of the Genetic algorithm

The figure 15 shows the overall output of the processes of the genetic algorithm, the different parts of the images are described from left to right from the top as follows. (a) Shows the fitness value of the best individual of each generation. (b) Shows the values of the best genes of the current best individual. (c) Shows the Best and Worst individual fitness value and also shows the mean fitness of each generation. (d) Shows the best individuals selected for crossover and the number of children they produce. (e) Shows the stopping criteria.

There are basically two stopping conditions which are based on the number of generations, for example we can stop the genetic process if the number of generations reaches 100. We can also stop the genetic process if the individuals stall (i.e.) there is no more further development in the fitness of the individuals. After the stopping condition is achieved; decision is made whether the image has been identified or not.

Results and Discussion

The image in figure 16 shows the skin detection of the clipped face image. From the image shown it can be seen that the outline of the skin in the image is perfectly outlined. Based on the identified skin in the image the face is marked based on which the face identification is done perfectly.

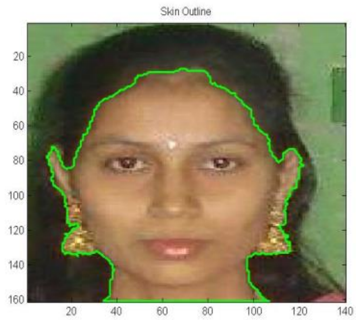

Figure 16. Shows the face skin outlined image.

The face marked image is shown in the figure 17. Based on the detected face in the input image the final face identification process is perfected.

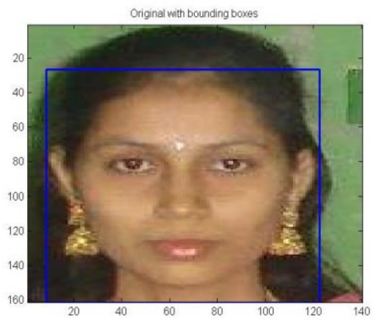

Figure 17. Shows the face detected and marked image

The final face identification is done by genetic algorithm and hence the output is either the face is identified or not, both the cases are shown in the figures 18 and 19.

Figure 18. Shows the output of successful face identification.

Figure 19. Shows the output of a failed face identification.

The success and failure of face identification means that either the input face image is available in the database or not available in the database (i.e.) either the face is authenticated or not authenticated.

From this system we have also generated a technique to detect multiple faces available in the input image. This is done by extracting the face features in the given image and hence count the number of faces based on clustering the face features. Though the algorithm is not perfect in detecting all the faces available in the image the output of the system is shown in the figure 20.

Figure 20. Multiple face detection.

A comparison chart is shown in the table 1 shown below. It compares the number of subjects used in the algorithm with the successfully recognized and unrecognized test images with the efficiency of the Face Identification System employed in this research work.

Table I. The efficiency of ACOGA algorithm

Subjects	Successfully recognized Test Image	Unrecognized Test Image	Efficiency (%)
5	4	1	80
10	8	2	80
15	13	2	86.6
20	18	2	90
25	24	1	96
30	28	2	93.3

The efficiency of ACOGA algorithm is shown in the above table. The results of testing the algorithm with different number of subjects and the number of images left unrecognized are tabulated in the table. The same is represented graphically in the figure 21.

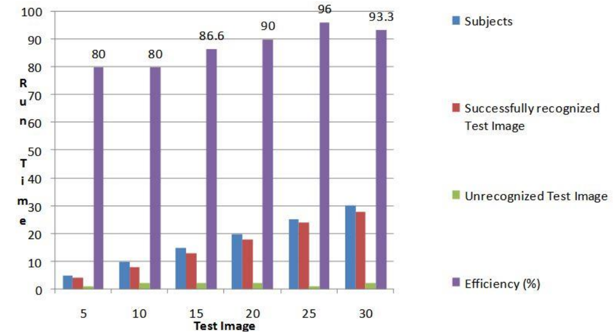

Figure 21. Graphical representation of efficiency of ACOAC algorithm.

There are a number of different face recognizing and identification method which varies on different grounds and are employed for different scenarios. Those methods are employed in the system for which FIS is developed and their results are compared in the table 2 and the same is represented also.

Table II. The efficiency of ACOGA algorithm when compared with other algorithms.

S.No.	Method	Test Image	Recognized Test Image	Un Recognized Test Image	Efficiency %
1	Active Appearance Model	25	20	5	80
2	3-D Morph able Model	25	22	3	88
3	3-D Face Recognition	25	23	2	92
4	Bayesian Framework	25	19	6	76
5	Support Vector Machine	25	18	7	72
6	HMM	25	21	4	84
7	Boosting and Ensemble	25	20	5	80
8	PCA	25	21	4	84
9	ICA	25	19	6	76
10	LDA	25	20	5	80
11	EP	25	21	4	84
12	EBGM	25	22	3	88
13	Kernel Methods	25	18	7	72
14	Trace Transform	25	21	4	84
15	ACOGA	25	24	01	96

It is clearly seen that our system tops the other methods with 96% efficiency. The graphical representation of the same is shown in the figure 22.

In this research work, a prototype for Face Identification System using the Soft Computing techniques like Genetic algorithm and Ant colony optimization algorithm is discussed. The experimental analysis shows that the above methods are more robust and suitable for low resolution, under shadow with different backgrounds and different facial expressions.

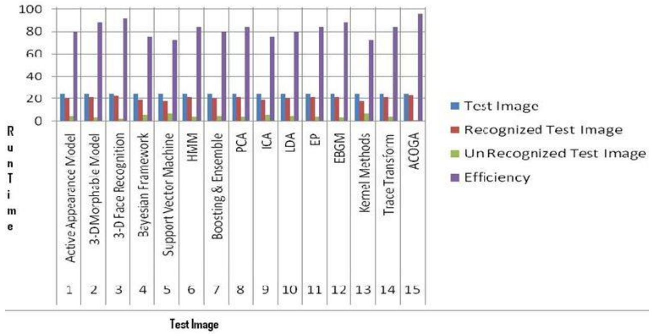

Figure 22. Graphical representation of efficiency of ACOAC algorithm when compared with other face identification algorithms

Conclusion

This Face Identification System by clustering Genetic and Ant Colony Optimization algorithm shows the maximum efficiency of 96%. This ACOGA competence can be greater than before by using better face scanner, best technique of scaling and well organized technique of edge detection and feature extraction of the face image. The problems faced while working on this research work are the difficulties in detecting faces of overlapping face images and detecting different face poses. In future the algorithm may be modified for different face angles and illumination variations and also to extend the algorithm to detect faces in video and live stream, hence we can detect faces in real time.

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