Face Detection and Recognition using Color Segmentation,Template Matching and Gabor Neural Network with Fuzzy System

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Face Detection and Recognition using Color Segmentation,Template Matching and Gabor Neural Network with Fuzzy System

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Abstract: Face recognition is the process of finding the face of one or more people in an image or even in a video. There are variety techniques for face recognition used in the researches. In this paper various algorithms for face recognition on mobile phones or other electronic device are applied. firstly the face detection should be implemented in any face recognition system. To get the face detection many algorithms like color segmentation, template matching etc are applicated. Then the second phase of the proposed algorithm is implemented by using neural network Gabor with fuzzy system. The algorithm has been represented using MATLAB and then implemented it on the device. While implementing the proposed algorithm, a tradeoff between accuracy and computational complexity of the algorithm are made, because the face recognition system is implemented on a device with limited hardware capabilities.

Keywords*: Face recognition, Face detection, Gabor Neural Network, Segmentation, Template Matching.*

كشف الوجه والاعتراف الشبكة العصبية كابور مع النظام الضبابي

ميس كريم جبار، مأب علاء حسين، ثائر عبد الرحيم

الخلاصة :
تقنية التعرف على الوجه هي عملية العثور على وجه واحد أو عدد من الوجوه للناس في صورة أو حتى في مقطع فيديو. هناك تقنيات متنوعة للتعرف على الوجه مستخدمة في اغلب البحوث. في هذا البحث يتم تطبيق خوارزميات مختلفة للتعرف على الوجه على الهواتف المحمولة أو غيرها من الأجهزة الإلكترونية. أولا يجب أن يتم تنفيذ الكشف عن الوجه في أي نظام خاص بالتعرف على الوجه. للحصول على كشف الوجه نطبق العديد من الخوارزميات مثل تجزئة اللون، قالب مطابقة وغيرها. ثم يتم تنفيذ المرحلة الثانية من الخوارزمية المقترحة باستخدام الشبكة العصبية كابور مع نظام ال Fuzzy وقد . تم تمثيل الخوارزمية باستخدام برنامج الماتلاب ومن ثم تنفيذها على الجهاز. في حالة تنفيذنا الخوارزمية المقترحة، يتم إجراء مقايضة بين الدقة والتعقيد الحسابي للخوارزمية، لأن نظام التعرف على الوجه يتم تنفيذه على جهاز مع قدرات الأجهزة محدود
الكلمات الرئيسية*: التعرف على الوجه، كشف الوجه، غابور الشبكة العصبية، تجزئة، مطابقة القالب .*

1. INTRODUCTION:

The task of finding a person's face in a picture seems to be effortless for a human to perform. However, it is difficult for a device with current technology to do the same. In fact, such a machine or system has been widely developed and actively studies in the field of image understanding for the past few decades, with take in mind applications such as machine vision and face recognition, a complex problem in image processing is automatic face detection were investigated. To solve this problem, many methods exist such as template matching, Fisher Linear Discriminant, Neural Networks, SVM, and MRC. Success has been achieved with each method to varying degrees and complexities.[1]

Over the last few decades, many works were done in face detection and recognition as it's a best way for person identification, because it doesn't require human cooperation so that it became a hot topic in biometrics. Many methods were introduced for detection and recognition which considered as a milestone. Although these methods were utilized many times for the same objective separately for finite number of datasets in past but there was no work found which provides overall performance evaluation of mentioned methods completely by testing them on tough datasets.

The combining of fuzzy logic and neural networks techniques suggested the novel idea of transforming the burden of designing fuzzy logic systems to the training and learning of connectionist structure and learning to the fuzzy logic systems and the fuzzy logic systems provide the neural networks with a structural framework with high-level fuzzy IF-THEN rule thinking and reasoning. These benefits can be witnessed by the success in applying euro-fuzzy system in areas like pattern recognition and control. Evolutionary Artificial Neural Networks have been widely studied in the last few decades. The main power of artificial neural networks lies in their ability to correctly learn the underlying function or distribution in a data set from a number of samples. This ability can be expressed in terms of minimizing the estimation error of the neural network, on previously unseen data [2], [3].This study is organized as follows. Section 2 has a generic face recognition system, Face Recognition Algorithm in Section 3, Section 4 has the proposed approach results, and The conclusion in Section 5.

2. A GENERIC FACE RECOGNITION SYSTEM:

An image or video stream are always the input of a face recognition system. The output is an identification or verification of the subject or subjects that appear in the image or video. Some approaches define a face recognition system as a three step process as seen in Figure 1. From this point of view, the Face Detection and Feature Extraction phases could run simultaneously.

Fig 1: A generic face recognition system.

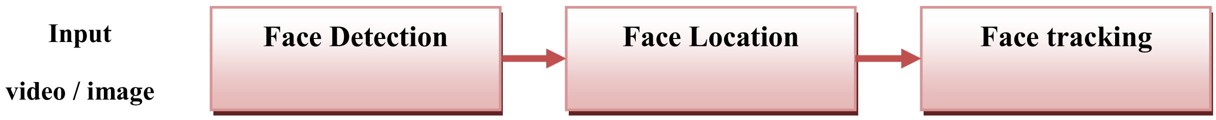
Face detection is defined as the process of extracting faces from scenes. So, the system positively determines a specific image area as a face. This procedure has many applications like face tracking, pose estimation or compression. The next step is feature extraction which involves obtaining relevant facial features from the data. These features could be certain face regions, variations, angles or measures, which can be human relevant (e.g. eyes spacing) or not. This phase has other applications like facial feature tracking or emotion recognition. Finally, the system does recognize the face. In an identification task, the system would report an identity from a database. This phase involves a comparison method, a classification algorithm and an accuracy measure. This phase uses methods common to many other areas which also do some classification process -sound engineering, data mining et al. These phases can be merged, or new ones could be added. Therefore, many different engineering approaches can found to a face recognition problem. Face detection and recognition could be performed in tandem, or proceed to an expression analysis before normalizing the face. [4,5 ,6]

3. FACE RECOGNITION ALGORITHM:

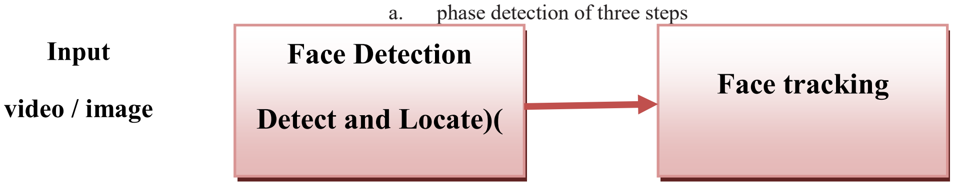
The designed algorithm in this study contains two phases. And each phase contains many parts to implemented in order to get a good face recognition system. Below the problems of face detection and recognition with the proposed algorithm will explained and how the proposed algorithm solve them.

3.1 Face detection problem structure:

Face Detection is a concept which includes many sub-problems. Some systems detect and locate faces at the same time, whereas others perform a detection routine at first, if it is positive, then these systems try to locate the face. Then, some tracking algorithms may be needed as seen in Figure 2 below.



a. phase detection of three steps



b. phase detection of two steps

Fig 2: Face detection processes.

The main steps in face detection and recognition algorithm are as the diagram below:

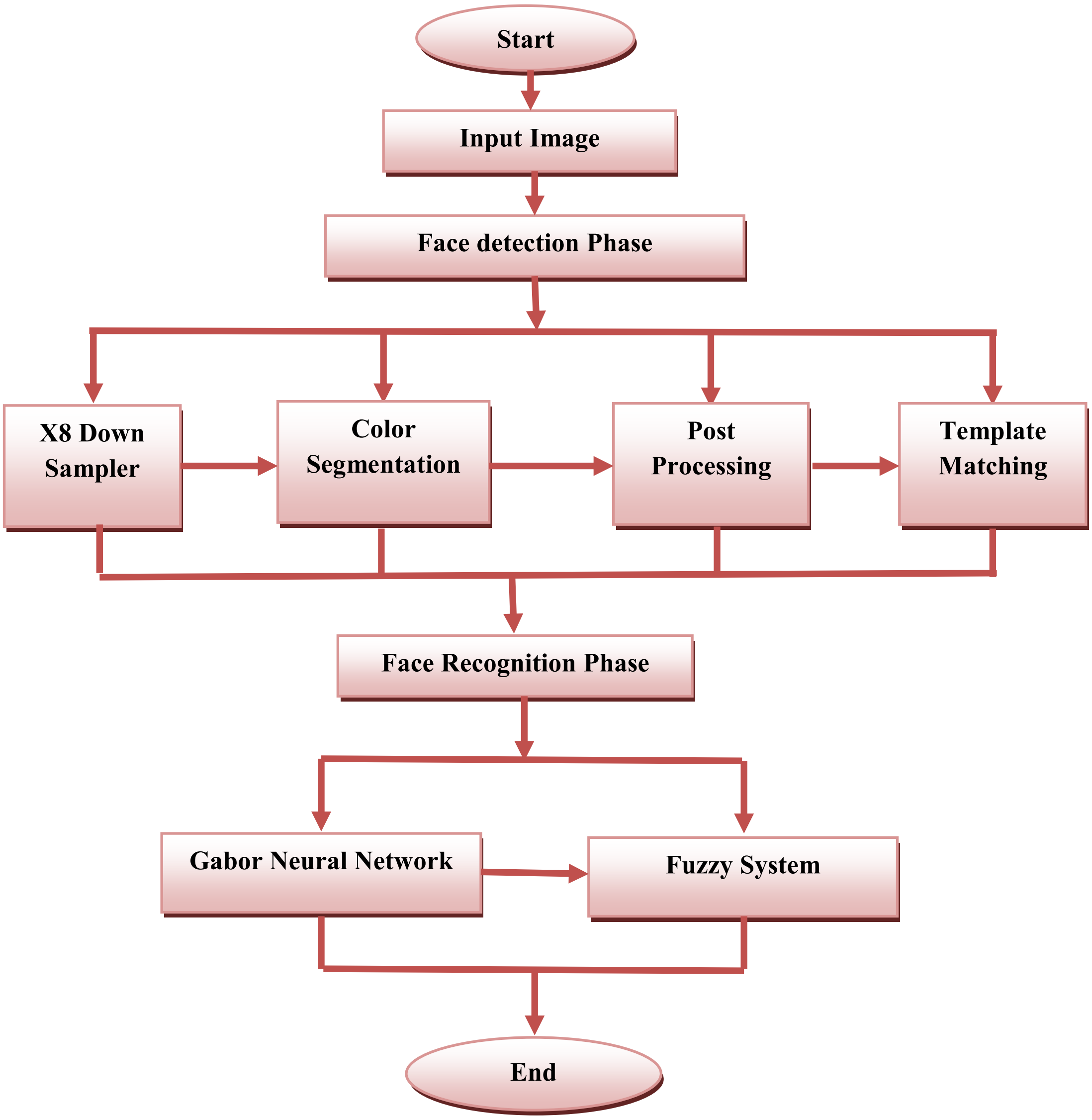


Figure 3. The Proposed Approach Algorithm

3.1.1. Face Detection Phase:

The face detection is the first step in face recognition algorithm. Color segmentation, morphological processing and template matching algorithms are used for the face detection. The following assumptions are made if the user takes the photo correctly:

- The face is centered and takes a big part of the image, since the photo is shot closely.
- The illumination conditions are correct.
- The user is facing the camera.

So the face detection does not need to use the most performing algorithm, this algorithm rather want an algorithm that can perform well and fast in the cited conditions. In consequence,

for face detection the following steps are used in the algorithm:

1. Use color segmentation to find skin pixels
2. Use morphological operations to eliminate isolated pixels.
3. Use template matching to extract only the face, which we will use for face recognition.

1. Color Segmentation:

Detection of skin color in color images. In the skin color detection process, each pixel was classified as skin or non-skin based on its color components values. The color segmentation can be done in many different ways, with some very advanced methods to process the images in extreme illumination conditions or with a cluttered background. Here a simple rule was found to detect the skin pixels as fast as possible. Two methods in particular were explored.

First step can work in the RGB space to avoid any calculation. The rule is modified from A pixel with color values (R, G, B) is classified as skin if:

- R > 95 and G > 40 and B > 20 and
- R > G and R > B and
- R-G > 15

Normalized RGB is a representation, that is easily obtained from the RGB values by a simple normalization procedure:

$$r = \frac{R}{R+G+B} \quad g = \frac{G}{R+G+B} \quad b = \frac{B}{R+G+B} \tag{1}$$

Where RGB is a color space originated from CRT display applications, which describe color as a combination of three colored rays (red, green and blue). It is one of the most widely used color spaces for processing and storing of digital image data.

As the sum of the three normalized components is known (r + g +b = 1), the third component does not hold any significant information and can be omitted, reducing the space dimensionality. The remaining components are often called "pure colors".

This algorithm performed well in general, but one wanted to explore other options, in particular because the speed of the RGB classifier was slower than expected. Other widely used color segmentation methods are based on Cr or Hue classifiers. Cr mains: Color is represented by luma (which is luminance, computed from nonlinear RGB was constructed as a weighted sum of the RGB values, and two color difference values Cr and Cb which are formed by subtracting luma from RGB red and blue components as

$$Y = 0.299R + 0.587G + 0.11B$$
$$Cr = R - Y$$
$$Cb = B - Y$$

Hue defines the dominant color (such as red, green, purple and yellow) of an area, saturation measures the colorfulness of an area in proportion to its brightness [7].

The algorithm tested various rules for Hue[8], but the classification can be too strict or on the contrary too loose for some lighting conditions. The color segmentation observed at size of mask 200 as in Figure (5) and if size of mask is changed from 200 to 100 that lead more than skin pixels it will be shown as in Figure (6) and Figure(7).

2. Morphological Image Processing:

After color segmentation, a mask of non-skin pixels is obtained. However this mask is not perfect: some sparse non-skin pixels are still visible while some parts of the face can be masked (see figure.5). Morphological image processing is thus a good way to eliminate the non-skin visible pixels and regroup the skin pixels by:

1. Perform erosion to remove sparse non-skin pixels.
2. Perform dilation with a larger disk to regroup the skin regions and smooth their contours. The disk diameter is bigger when scale-by-max is used because more skin pixels have been misclassified.

More complicated morphological operators can be designed by means of combining erosions and dilations.

Erosion :

The main objectives of erosion are:

- Used to reduces objects in the image

- Definition, binary images:

– The positions where a given structure element fits

$$\varepsilon_B(X) = \{|B_X \subseteq X\}| \quad (2)$$

where B_X means B translated with x, X is the image, and B is the structure element.

- Definition, grayscale images:

Where remember the definition for binary images:

$\varepsilon_B(X) = \{|B_X \subseteq X\}|$Can be rewritten into the intersections of the translated sets X_{-b} :

$$\varepsilon_B(X) = \cap_{b\in B} X_{-b} \quad (3)$$

Which can be extended to also include grayscale images:

$$\varepsilon_B(f) = \wedge_{b\in B} f_{-b} \quad (4)$$

Dilation:

The main objectives of dilation are:

- Used to increase objects in the image .
- Definition, binary images:

– The positions where a given structure element fits

$$\delta_B(X) = \{X|B_X \cap X \neq \emptyset\} \quad (5)$$

where B_X means B translated with x, X is the image, and B is the structure element.

Definition, gray scale images,

the definition for binary images is:

$$\delta_B(X) = \{X|B_X \cap X \neq \emptyset\}$$

Can be rewritten into the unions of the translated sets X_{-b} :

$$\varepsilon_B(X) = \cap_{b\in B} X_{-b}$$

Which can be extended to also include grayscale images:

$$\varepsilon_B(f) = \vee_{b\in B} f_{-b}$$

Below is a sample output of the color segmentation and morphological processing stages. The original image shown in figure4.

Fig (4) Original image

Fig (5): Color Segmentation Morphological Processing at Size of Mask 200

Fig (6): Color Segmentation and Morphological Processing at Size of Mask 100

3. *Template Matching*:

After color segmentation closing, and morphological image processing, template matching are used to isolate faces from non faces. Template matching is used as a final step in the face detection process. Template matching is a process of locating an object represented by a template T(x, y) in an input image I(x, y) by cross-correlating the input with the template. Down sampled output of the color segmentation and morphological processing stages are used as an input to the template-matching block. A standard template (average of around 400 faces, both male/female and people from different ethnic backgrounds) is taken from the Internet. Then normalized 2D cross-correlation is performed with the given input image to obtain the position of the face. also try to manually generate the standard template using the training images that is taken from the phone or any device. Standard template used is a gray scale image. So, input image is converted to gray scale and then cross-correlated with the template. The standard template used for matching purpose is shown in Figure (7).

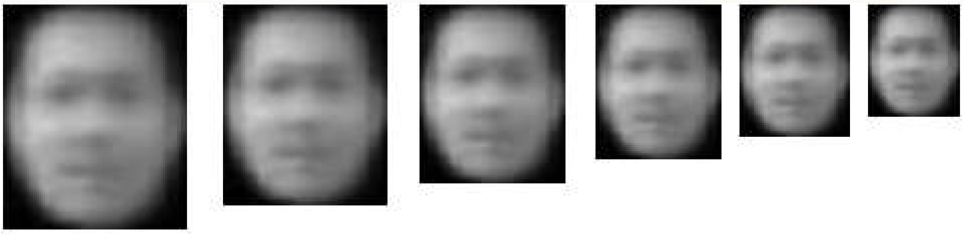


Fig (7): Face Template Matching

3.1.2. Face Recognition Phase:

In this phase the neural fuzzy system used to get a face as explain in the following algorithm:

3.2 Gabor Filter Neural Network with Fuzzy for Face Recognition System (GFNFFR):-

In this study, the fuzzy neural network for face recognition is used, this algorithm implemented in two phases. A face recognition system using a Fuzzy Multilayer Perceptron (MLP) [9]. The idea behind this approach is to capture decision surfaces in non-linear manifolds, a task that a simple MLP can hardly complete.

Phase One :

For neural network a Gabor wavelet is used, which achieves face recognition by implementing a MLP with back-propagation algorithm. Firstly, there is a pre-processing step. Every image is normalized in terms of contrast and illumination. Noise is reduced by a "fuzzily skewed" filter. It works by applying fuzzy membership to the neighbor pixels of the target pixel. It uses the median value as the 1 value membership, and reduces the extreme values, taking advantage from median filter and average filter. Then, each image is processed through a Gabor filter. The filter is represented as a complex sinusoidal signal modulated by a Gaussian kernel function.

The Gabor filter has five orientation parameters and three spatial frequencies, so there are 15 Gabor wavelets. The architecture of the neural network is illustrated in Figure 8.

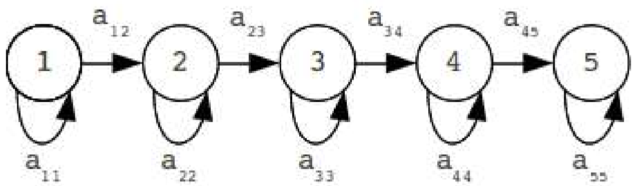


Fig 8: 1D-HDD states.

To each face image, the outputs are 15 Gabor-images which record the variations that measure by the Gabor filters. The first layer receives the Gabor features. The number of nodes are equal to the dimension of the feature vector containing the Gabor features. The output of the network is the number of images that the system must recognize. The training of the network, the back propagation algorithm, follows this procedure:

1. Initialization of the weights and threshold values.
2. Iterative process until termination condition is fulfilled:

(a) Activate, applying input and desired outputs. Calculate actual outputs of neurons in hidden and output layers, using sigmoid activation function.

(b) Update weights, propagating backwards the errors.

(c) Increase iteration value.

Phase Two:

Then, the output vectors obtained from that step must be fuzzified. This process is simple: The more a feature vector approaches towards the class mean vector, the higher is the fuzzy value. When the deference between both vectors increases, the fuzzy value approaches towards 0. The selected neural network is a MLP using back-propagation. There is a network for each class. The fuzzification of the neural network is based on the following steps: The patterns whose class are less certain should have lesser role in weight adjustment. So, for a two-class (j and i) fuzzy partition $\varphi i \ (x_k)$ k = 1, . . . , p of a set of p input vectors,

$$\varphi i = 0.5 + \frac{e^{c(dj-di)/d} - e^{-c}}{2(e^{c} - e^{-c})} \qquad (6)$$

$$\varphi i = 1 - \varphi i(x_k) \quad (7)$$

where di is the distance of the vector from the mean of class i. The constant c controls on the rate at which fuzzy membership decreases towards 0.5. The contribution of x_k in weight update is given by $| \varphi 1\ (x_k) - \varphi 2\ (x_k)\ |^m$, where m is a constant, and the rest of the process follows a usual MLP procedure.

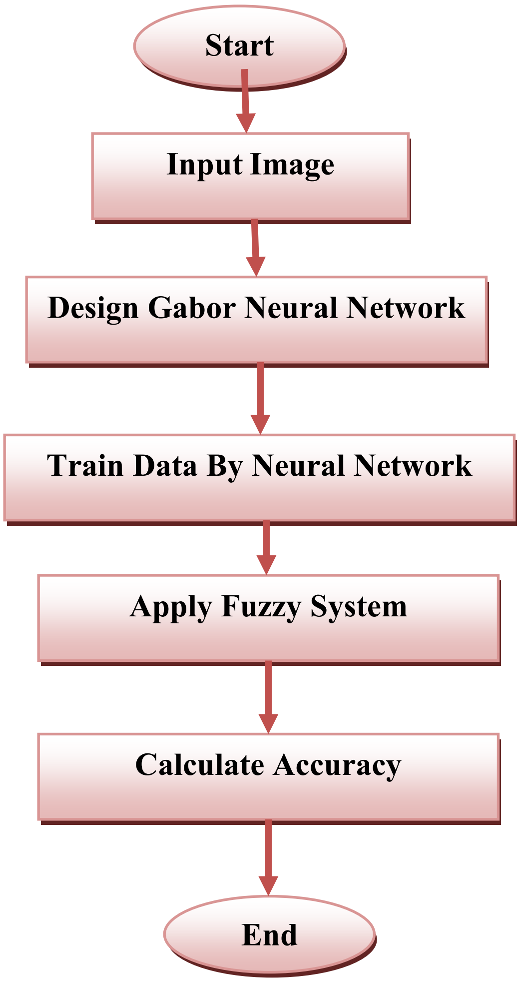


Fig (9) Flowchart of Face Recognition Phase

4. *The proposed Approach Results*

In this section, one can see the important results that show the efficiency of the proposed Gabor Filter Neural Network with Fuzzy for Face Recognition System (GFNFFR):

1. *Accuracy:*

The accuracy of the proposed approach GFNFFR when neural network with the fuzzy system technique is calculated and compared it with the accuracy in case of using only neural network .The result of comparison is shown in Figure 10 below:

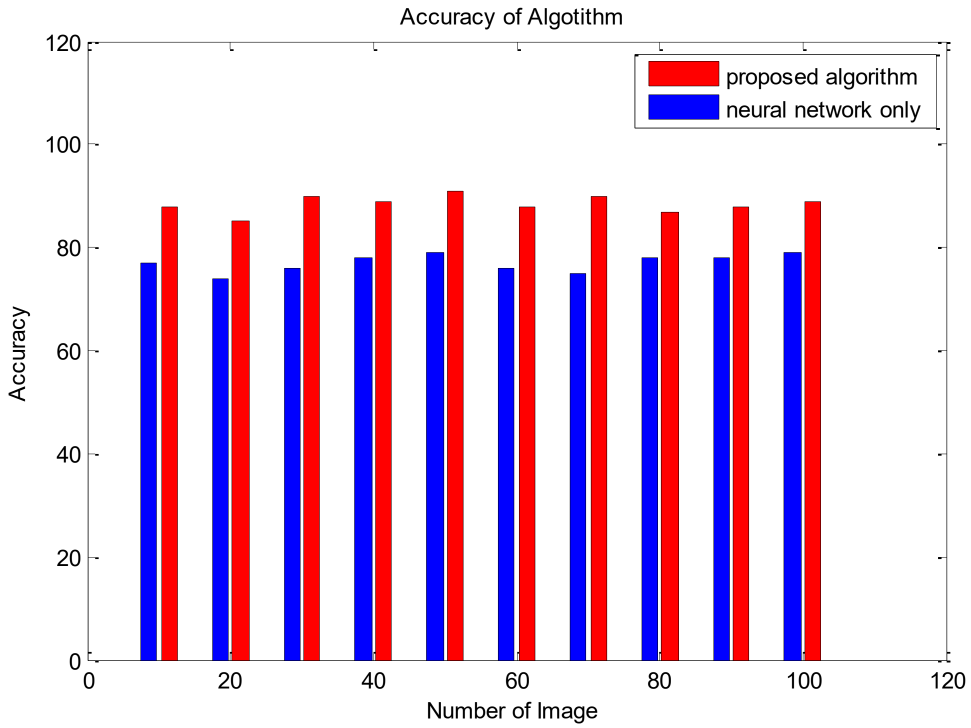


Fig 10. Accuracy of the proposed algorithm

As seen from figure 10, the accuracy is varied between 70 to 78 when only neural network technique is used. But the proposed algorithm accuracy is ranged between 85 to 90. That mean high accuracy is obtained for the proposed algorithm. High accuracy is maintained even when the number of images increased

2. *False Acceptance Rate and False Rejection Rate:*

The proposed algorithm GFNFFR will be compared with the algorithm without fuzzy system in terms of False Rejection Rate (FRR) , False Acceptance Rate(FAR), and Equal Error Rate (EER). FRR and FAR are computed using equation 8 and equation 9 respectively. Then, EER is equal (FRR+FAR)/2.

FRR: The algorithm may fail to detect the face.

$$FRR = NFR/NAIF \quad (8)$$

Where NFR is the Number of false rejection rates and NAIF is the Number of attempts to identify a person's face

FAR: The probability that the algorithm determines the wrong face.

$$FRR = NFR/NIIA \quad (9)$$

Where NFR is the Number of false rejection rates and NFIA is the Number of face identification attempts.High reliability can be obtained for the proposed algorithm when the EER is small.

Table (1): Comparison of FAR , FRR, and EER with and without using fuzzy system

Algorithm	No of Images.	FAR	FRR	EER
The proposed approach with neural and fuzzy	5 10 20 50	2 4.3 6 8	15 13 12 10.5	8.5 8.6 9 9.25
The proposed approach with neural only	5 10 20 50	4 6 8.5 10	17 16 14.5 14	10.5 11 11. 5 12

From the above table one can conclude that the performance of the proposed face recognition algorithm GFNFFR gives better performance comparison the case of not using fuzzy in the face recognition phase. EER for the proposed algorithm with neural and fuzzy is smaller than EER for the algorithm with neural only. These indicate that the high reliability of the proposed approach has been obtained.

4. Conclusion

In this work, the system was developed that various algorithms were investigated to evaluate the face recognition on mobile phones or other devices. Which was considered to be implemented in two steps, each step has many phases. Color segmentation, Morphological operation (opening) and template matching were used for face detection. Finally, face recognition algorithm was implemented, which depended on neural fuzzy system. One can conclude that the best performing technique is implemented with the use of neural and fuzzy system, which gave a good results. This algorithm conceder two parts to perform face recognition phase. The first phase is neural network for training input images. The other phase is fuzzy system, which helped to improve the performance results in face recognition. From the results one can conclude that our algorithm GFNFFR gave better accuracy as compared to case without fuzzy. Small EER was obtained, which showed the strength of the proposed approach compared with the algorithm with neural only.

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Symbols:

c: controls the rate at which fuzzy membership decreases towards 0.5.

d_i : the distance of the vector from the mean of class i.

m: a constant.

P: input vectors.

x_k : Fuzzy partions.

φi(xk): fuzzy partition.

φ_i, φ_j : classes.