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A Combination of Fuzzy Interface System (FIS) and IWO Algorithm to Improve Angular Face Recognition

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Abstract: In this study, face recognition in angled status using invasive weed optimization algorithm is studied. Invasive weed optimization algorithm is one of the most recent optimization algorithms in evolutionary algorithms family. Combined with other existing algorithms, invasive weed optimization algorithm proposes an appropriate approach in order to an improved solution. In this study, a combination of fuzzy cost function and invasive weed optimization algorithm is used in order to human face recognition. Fuzzy logic is used in order to face recognition in angled status and invasive weed algorithm is used in order to obtain the optimal threshold to find the favourable solution. Tests conducted on the proposed algorithm shows 91.4% of existing faces in MIT database.

Key words: Invest weeds optimization, posed face detection, fuzzy system face detection, image processing, optimal threshold

INTRODUCTION

Digital image processing and face recognition in these images have always been one of the main challenges in security companies, hospitals, computer game providing companies, etc. With the spread of digital images due to the increase of cameras and mobile phones the need to devise a comprehensive way to identify and recognize people in pictures in research fields have been suggested more and more. Therefore, much researches has been done in this direction including (Zhou *et al*., 2013) that combines PCA and LDA with a support vector machine in order to face recognition. The PCA is used for image reconstruction as well as dimension reduction. The LDA is used in order to face recognition and obtain the coefficient matrices and the SVM is used for training and testing the system.

The LDA integrates data distribution in obtained subspace compared to Eigenface using within-class and between-class scatter matrix construction and maximize the between-class scatter matrix measure while minimizing the within-class scatter matrix measure. One of the advantages of this system is the ability to learn inner class variation ranges preparing images with the change of corresponding characteristics. But to implement a proper system, a large number of images are needed and all changes cannot be recorded all the time. On the other hand, in (Zhang and Guo, 2012) a cascade face recognition method using two dimensional wavelet and artificial neural network is used. Other conventional methods include fisher face, Eigen face and Elastic Graph Matching (EGM). The Eigen face method was proposed by Turk and Pent Land that used main element analysis or PCA to reduce dimensions in order to find a subspace with orthogonal vectors to show data distribution in the best way. When this subspace is applied on the face is called face space. After vectors are determined, all images are transferred into this subspace in order to obtain the weights that express images. Comparing the similarities of existing weights with the weight of new mage transferred into this subspace, input image could be detected. The key point of this method is using Karhumen-Loeve transform. If the image elements are considered as random variables, the image can be considered as statistical samples (Shin *et al*., 2007).

Karhunen-Loeve's transform is used to produce a series of Eigen vectors with much less dimensions than the main covariance matrix. The main purpose is defining initial image by a linear combination of Eigenface matrices. Eigenface are obtained by projection of the original picture on the selected eigenvectors. The important feature of the system is quick implementation without complexity but it is too weak when light intensity and face angle changes (Zheng *et al*., 2008).

Low reliability and classification time of faces found in images with angled status caused us to do a more thorough study in order to find a solution to improve proposed methods mentioned above.

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In Fisher Face performance is improved using fuzzy cost function and KNN is utilized to perform classification (Kwak and Pedrycz, 2005). This method has initialized the matrix elements using a fuzzy cost function. This reduces the sensitivity to noises. A method is proposed in (Song *et al*., 2010) which are based on LDA and SVM methods fuzzification that causes using non-classifiable areas. Although, this method has high computational load but the problem can be solved using a combination of decision trees with FSVM. Also, FKNN-based FLD is used for feature extraction.

In a fuzzy method is proposed that implements Face detection independent of the status, size and position of the face (Pentland *et al*., 1994). Using Subtractive clustering in order to make decisions about the number of membership functions is one of the features of this method. Parameters such as the color, the lips status and general information of face shape and also using the features of the ear texture are some of the basic parameters of this method. Then the genetic algorithm is used to determine the threshold value. In (Moallem *et al*., 2011; Liang *et al*., 2008) using neural networks is the main field of research. Neural networks that have been used in many problems of pattern recognition and automated robots riding can be easily trained to record highly complex status of face pattern (Jing and Chen, 2009). But still, the network should be set to achieve outstanding performance and should be designed for a particular activity.

For instance, only frontal face images with a gray scale can be recognized. In reference (Rowley *et al*., 1996) a face recognition algorithm is proposed based on light compensation technique and a nonlinear color transformation that can be used in a wide range of skin color is also proposed. Unfortunately, this algorithm cannot detect faces with all status. In this model we seek to find a basic vector that data (images) does not have statistical subscription after applying Projection on them. This is obtained by maximizing quadratic dependence and higher levels of data. Two implementation models are introduced and inherit the strengths and weaknesses of computational algorithms in subspace due to the lack of dependence on any of the internal features of the face. In fact, most of the activities done in face recognition field are devoted to a particular status.

Then the importance of fuzzification of different parts gained more attention such that fuzzification idea of assigning classes has existed for a long time and it can be dated back to publication of the results of Keller *et al*. (Hsu *et al*., 2002; Hashemi *et al*., 2015) that was in a subset of the Kth nearest neighborhood. One of the most important esearches about the way of changing the face is done by Ekman which led to the development of FACS (Facial Action Coding System). In FACS each action unit refers to a change in face that cannot be performed alone firstly and secondly is not dividable (Keller *et al*., 1985). In study (Hashemi, 2015a), it is assumed that there is a model of the face in different scales from large to small. Then the image is searched for the largest scale of the face model. If one matching is found, the image is searched by a smaller face model scale and this trend will continue as far as the smallest possible face scale found in the image.

This method is sensitive to rotation and is difficult for faces hat are not in front façade. In (Haddadnia and Ahmadi, 2004; Zangian *et al*., 2014) an effective way to find a face in color image based on fuzzy logic is presented which acts by applying the measure function and fuzzy distances. The AAM is a manual model (in some of automated systems) made of hotspots and important faces features and system fits the developed model on input images for recognition. The developed model deforms using the inner training group images and final features for distance classification and accuracy in fit phase and mounting the model on the face.

The well-known Lucas Canade model is used in this phase. In study (Campos *et al*., 2001; Hashemi, 2015b) a method is developed in which the face matrix histogram with the average of rows is used as the criterion for the detection of faces in an image; in a way that some areas of the image are candidate based on skin color and then using the mentioned index and fuzzy logic, faces are recognized and the exact location will be determined in the original image. The problem with this method is inefficiency in identifying faces in pictures with moustache and beard. In (Zhang *et al*., 2008; Shin *et al*., 2007). Franco and Treves (2001) proposed a method to recognize the status of happiness, sadness and wonder processing these status. They considered the face symmetry and divided a part of the right half of the face that was focused to the tip of the nose and then split it into 2*2 windows and extracted features such as pixel variances, developed the feature vectors and rained a neural network in order to recognize different face status using those vectors (Hashemi and Broumandnia, 2015a).

In all the methods mentioned above there is a shortcoming and that is the recognition of faces when the person is not in a frontal facade status and is angled from 15-90°. Tests indicate poor performance in the most of mentioned methods. So, the need to do existing research and using evolutionary algorithms in order to improve above mentioned methods was proposed.

In this study a combination of fuzzy cost function and invasive weed optimization algorithm is proposed and the structure is explained in the following.

MATERIALS AND METHODS

The proposed method in this study is a combination of fuzzy cost function of lip, eye and face areas recognition and invasive weed optimization algorithm in order to find the optimum threshold to differentiate the background colour and skin area and picture segmentation processes. In this solution, it is tried to focus on face pictures with the angle from 10-60° and also front facing mode (full-face) is considered. However, this method focuses more on angled face recognition. Further explanations on different parts of the proposed system are given in the following sections.

Fuzzy inference system (Moallem *et al.*, 2011): In the proposed method a Fuzzy Inference System including FISs to recognize face skin, lips and angled faces as well as front facade faces. The suggested fuzzy inference system is as follows: Different parts of a fuzzy inference system are introduced in the following (Fig. 1):

- Rule base including a set of if-then rules
- Database including MF membership function definitions from fuzzy sets
- Fuzification interface in order to map crisp amounts to fuzzy amounts
- Decision making in order to providing the inferences operations on rules and create fuzzy results
- Fuzzyfication interface to map fuzzy results into output crisp amounts

In a fuzzy inference system the goal is to input a series of data and enforce the If-then rules that cause the fuzzy output between 0 and 1. This variable increases the accuracy of different systems (Moallem *et al.*, 2011). FISs related to skin, lip, eye, full face and side view are considered as follows:

- Recognition of skin area in input image
- Recognition of lip area in recognized skin areas
- Recognition of the face in a short distance and close up view
- Recognition of the face in side view

Actually, there are four classifiers that each one made of a FIS and each is responsible for identifying a special part. Using this classification system practically the background areas is separated and lips and eyes areas are recognized (Fig. 2-4).

Colour system conversion: In order to enter this section first we introduce colour systems commonly used in artificial intelligence (Moallem *et al.*, 2011):

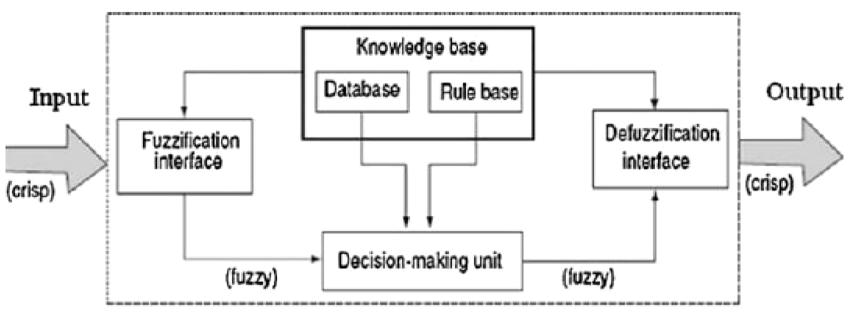

Fig. 1: General view of a inference system (Moallem *et al.*, 2011)

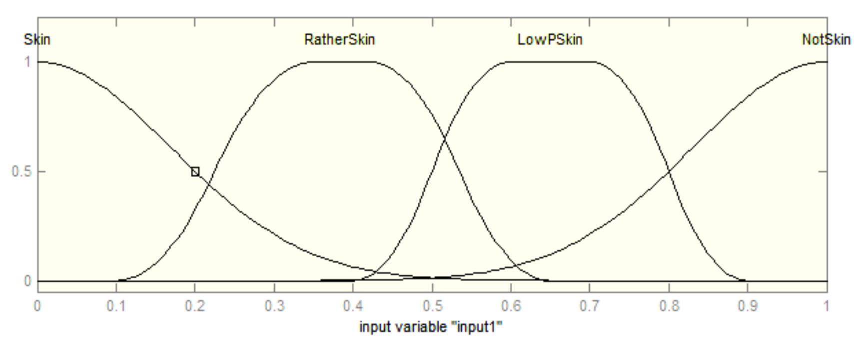

Fig. 2: Skin and non-skin recognizer FISs

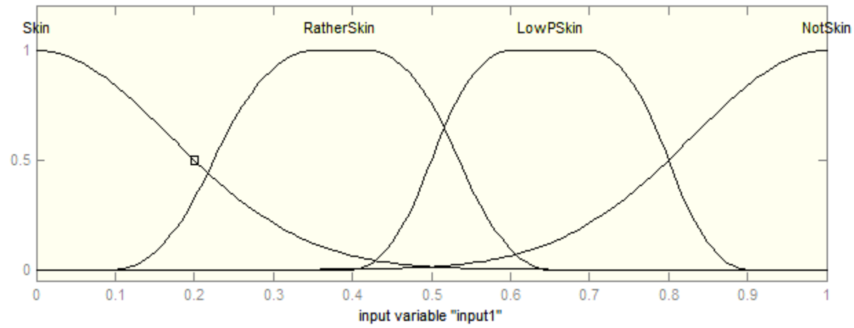

Fig. 3: Lip and non-lip areas recognizer FISs

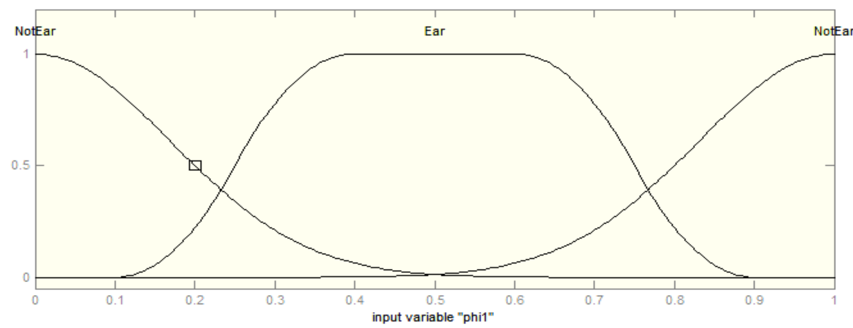

Fig. 4: Shows the combination of the last status to recognize faces and non-face areas

- The base colour space (RGB, normalized RGB and CIE-XYZ)
- Perceptual colour space (including: HSL, HSV, HIS and TSL)
- Orthogonal colour space (YUV, YIQ, YC_B C_R ad YEs)
- Perceptual uniform colour space ($CIE\text{-}L_{AB}$ and $CIE\text{-}L_{UV}$)
- Combined spaces and comparative spaces

In order to utilize face images in our proposed system we transfer input images from RGB color system into HSV system (Hashemi and Broumandnia, 2015b). HIS environmental color system (color-saturation) was proposed when users needed the color features to be shown as numbers.

These color environments are based on what is received by the visual system of human being. The HUE presents the color range of an area (such as red, green, purple and yellow), saturation presents the rate or saturation of the color and intensity presents the lightness or value of the light. High sensitivity of components and high distinction between the elements of color and light makes this color environment available as a known method to separate the shadow. The transform equation of RGB into HSV is as follows:

$$H = \arccos\frac{\frac{1}{2}\left((R-G)+(R-B)\right)}{\sqrt{\left((R-G)^2+(R-B)(G-B)\right)}}$$

$$S = 1-3\frac{\min(R,G,B)}{R+G+B},\ V = \frac{1}{3}(R+G+B)$$

$$X = S\cos H,\ Y = S\sin H$$

Some of the undesirable features related to these color environments are: HUE irregularity and lightness calculation that interference with undesirable features of visual color characteristics (Moallem *et al*., 2011; Hashemi, 2015a, b).

In this study, thresholding is used in order to separate the background color and a person’s face in the image. Next improvement of thresholding in images used by invasive weed optimization algorithm is thoroughly explained (Moallem *et al*., 2011).

Invasive weed optimization algorithm: This algorithm is defined considering the behavior of weeds in nature and is one of the evolutionary algorithms in order to be utilized in optimization. Invasive weed has a regular structure of improvable behaviors. Initially the seeds are released randomly in the environment. Considering environmental conditions, these seeds grow and reach

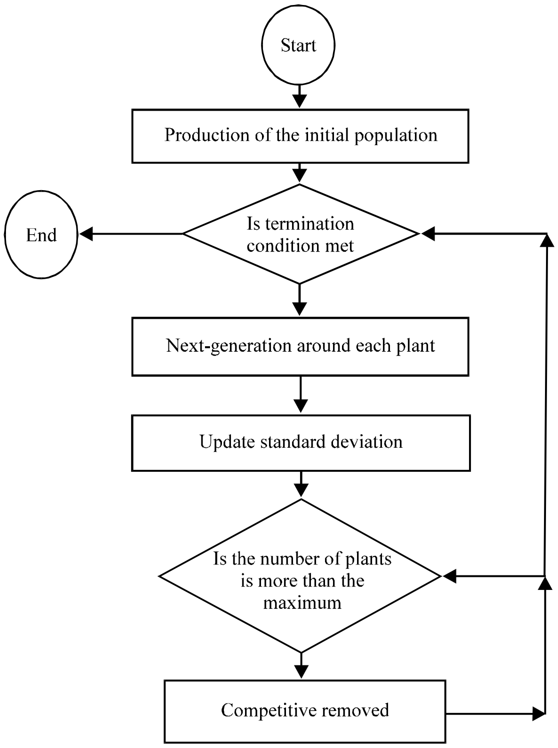

Fig. 5: IWO creating the next generation

maturity. General flow chart of invasive weed algorithm is a following: Generally, invasive weed optimization algorithm implementation steps are as follows (Fig. 5):

- Creating initial population of weeds randomly and evaluating the objective function
- Reproduction of seeds depending on their fitness value and updating standard deviation (environmental distribution)
- Standard deviation depends on the number of irritations, at the beginning of the algorithm the level of standard deviation is high (seeds are scattered) and vice versa
- Competitive exclusion: when the number of weeds exceeds what is determined earlier, they will be eliminated by algorithm depending on competency
- Checking the termination condition

Creating initial population: In this step as the first step of algorithm, a predetermined number of weed seeds are distributed in the environment. Considering the inherent integration of this algorithm and discretion of face recognition problem we discrete the problem as follows: As shown in Fig. 6, we prioritize the weed seeds based on their competency from 1-5. Following algorithm is utilized to produce initial population: As it is clear, a threshold

Fig. 6: A bit of the fitness

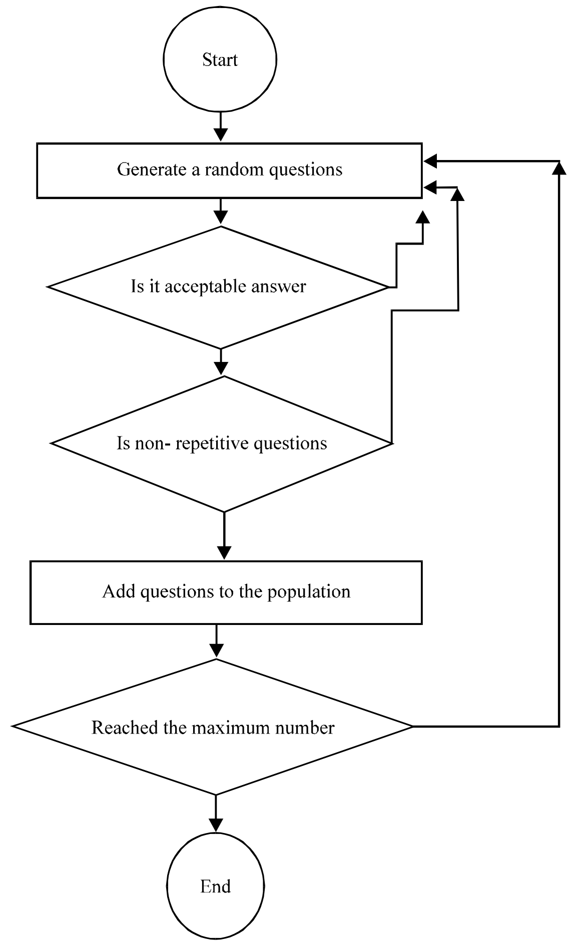

Fig. 7: IWO general flow chart

value as N_{weed} is defined. Produced seeds should not exceed this threshold value (Fig. 7).

Reproduction: After a specialized time period, scattered seeds are changed to matured plants and assign a fitness function to themselves based on their power. Each member produces the seeds of the next generation based on mentioned fitness. As the fitness of a plant increases, the produced seeds will increase subsequently. Figure 8

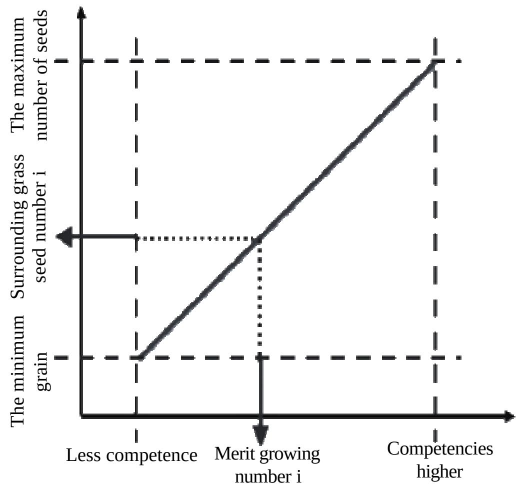

Fig. 8: Fitness impact on the number of created seeds Chart (Moallem *et al*., 2011)

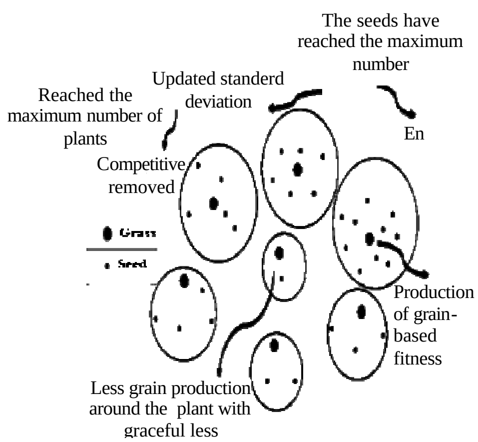

Fig. 9: The standard deviation in the near seeds created around each plant

clearly shows the effect of fitness on the number of seeds. S_{min} and S_{max} stand for the minimum and maximum of produced seeds (Fig. 9).

Standard deviation and its impact on production of powerful population: The rule in nature that a team work as well as a population is more powerful than a single person has always been used to proposed innovative algorithms that is originated from the reality of life and universe. This issue is exactly presented as a standard deviation in invasive weed algorithm and it is tried to decrease the gap between the generations and seeds in each population in order to empower the population. Actually, this leads the finesses created by a plant to increase. This is fully shown in Fig. 9. At the beginning of the algorithm and in order to spread the produced seeds, an initial standard deviation is defined randomly which is shown by $\delta_{initial}$. Final standard deviation created is also shown by δ_{final}.

Competitive exclusion: In this step, survival law is mentioned. The strong will always survive and this is also true about the invasive weeds. So, the weeds with better fitness function will remain. Then in each irritation, weeds having less fitness function value will be excluded. Exclusion is done considering the predefined number of the most of weeds of the set. The maximum number of weeds are shown by P_{max}.

Termination condition: Each algorithm according to the existing rules should have a termination condition. Invasive weed algorithm also is no exception. Four conditions are considered in this algorithm:

- Achieving a desirable value: In this case, the algorithm ends after a few iterations, we have reached the desired solution
- No significant improvement after a certain number of irritations in algorithm. This case is the worst one possible for termination of algorithm because it has not reached the desirable value and there is no hope to achieve it
- Achieving the most number of irritations considered: Sometimes our goal is to reach a value after a certain number of irritations. In this case the desirable value is one achieved by N irritations
- The number of objective function predefined evaluation: in this case there is a predefined value and compare it to the desirable value in each irritation to check the convergence rate

The above presented algorithm is used in order to achieve the optimum threshold value in innovative system of this study. The achieved threshold value is used in order to identify the 0.8964 face skin. This means that amounts more or less than this number cannot be considered as skin colour.

RESULTS AND DISCUSSION

General algorithm: Based on the algorithm presented at the end of this section, initially the input image is processed primarily (pre-processed) and features related to the skin will be achieved using the optimized thresholding by invasive weed algorithm. Then the areas of lips, eyes and faces recognized in frontal façade and angled status will be shown in output using mentioned classifiers as well as fuzzy inference system. After

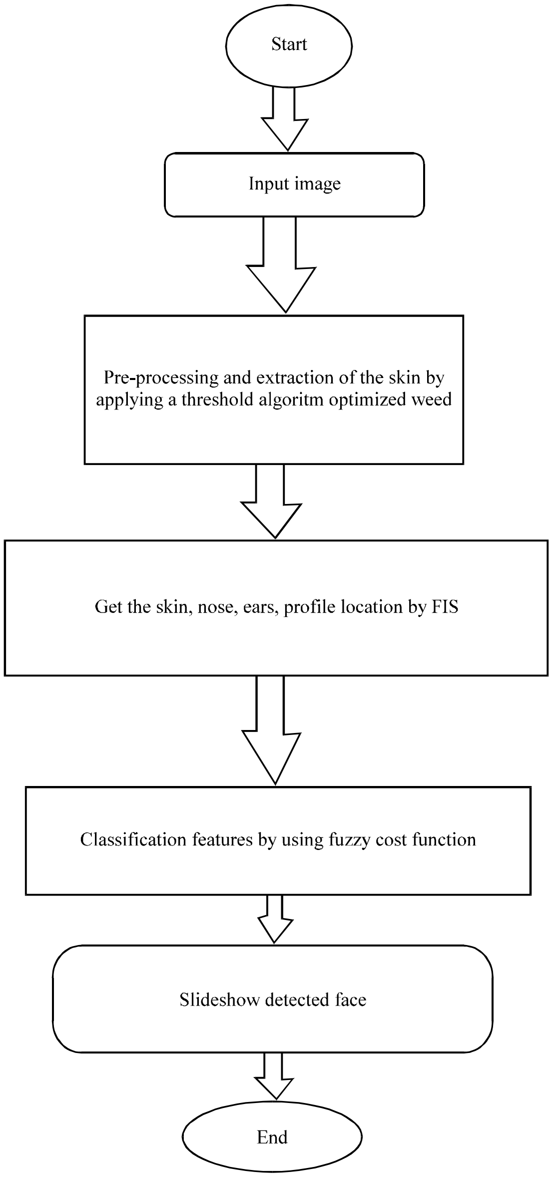

Fig. 10: Final algorithm flow chart for face detection (Deramgozin and Fard, 2016)

entering the picture to the proposed system for better separation of the face picture, colour conversion from RGB to HSV takes place and then a more accurate numerical value is obtained from the texture of the colour. The picture is then processed to extract features and apply the threshold and we have achieved the threshold value of 0.8971 using invasive weed thresholding system which is an optimum number (Fig. 10).

After splitting the face parts from the background colour the image is entered into the fuzzy system and is examined in frontal face (full-face) and angled mode and face, pretty faces and non-face modes are completely separated. Then non-face parts are removed and face or pretty-face modes are displayed (Fig. 11).

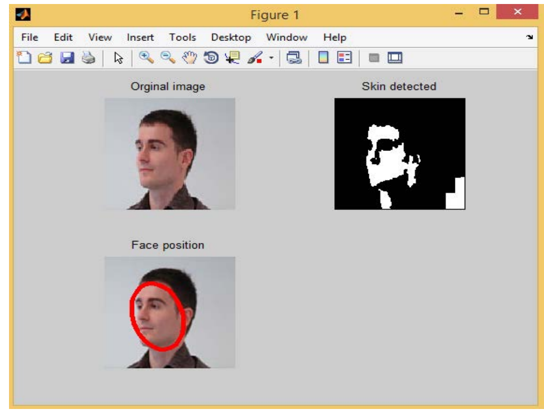

Fig. 11: Detected face skin and image

Table 1: Results of posed face detection algorithms

Parameters	Fisher (%)	Fuzzy-Ga (%)	FLDA-PCA (%)	Fuzzy-IWO (%)
Recognition rate	94.50	90.70	91.80	92.02
Correct recognition rate	93.00	90.00	89.00	91.00
Error rate	1.00	6.70	4.00	9.00

By examining the proposed algorithm on 200 images of ORL image database and 140 images of MIT dataset and compared to 3 methods including fisherface, fuzzy-GA and FD-PCA, the proposed algorithm was ranked as the second one with the rate of 92.02% correct image recognition in angled status among above mentioned methods. Table 1 shows the mentioned ranking.

As it is shown in table, the correct recognition rate of this algorithm has gained the second rate of accuracy and due to its unique structure. Fisher has always been able to properly identify more cases correctly. FLDA-PCA method has always been the weakest method among all mentioned methods and cannot be a proper method to recognize face images with angled status (Hashemi and Broumandnia, 2015c).

The strength of this algorithm is in angled mode pictures and sometimes applying the proposed algorithm on angled pictures between 23-60° a lot of failures are detected. This method combines genetic algorithms and fuzzy to find a good way for face recognition. But in terms of processing speed it slightly slows down and its popularity decreases.

CONCLUSION

Based on the experiments, the proposed method in this study is effective in recognizing faces in images, especially when the face is in angled status. The obtained results of the algorithm show the effectiveness in identifying images in 91% of the cases. Because of this percentage and also because of the relatively low processing speed of these types of algorithms, it seems that combining fuzzy systems and evolutionary methods is welcomed as long as the speed of processing is not important. However, they are not recommended in real-time systems and critical applications. Despite these problems, the use of modern evolutionary algorithms such as invasive weeds, dove and so on can create quality as well as increasing processing speed and finally a better and more desirable result is gained.

RECOMMENDATIONS

In the future, we seek to find optimized solutions considering all principals and utilize it in a processing and face recognition system. Interest in evolutionary algorithms has led more researches to be done on them and considering uncertainty in processing systems, these types of algorithms create new approaches to researchers.

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