Improved Fuzzy and Artificial Neural Networks based Skin Detection System for Effective Face Detection

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Abstract
Skin detection is one of the biometric methods that is used to identify any given face image using the main features of this face. In this research, skin detection for face recognition system is proposed based on Artificial Neural Network (ANN) method called as the Feed Forward Back Propagation Neural Network (FFBPNN). The ANN model is constructed with 7 layers input layer, 5 hidden layers each with 15 hidden units and an output layer. The Proposed System has three steps. Initially, the pixels of the different types of facial grey scale images are computed. Secondly, the computed pixels are compared with the original grey scale image based on the fuzzy rules. This process is done for the first pixel to the last pixel so that all the pixels which are present in the entire image can be included in the overall process. Finally, the FFBPNN is trained and tested for its accuracy of the face detection. The proposed system is tested with different facial images. The results of the proposed method were compared according with different existing methods to find the accuracy. Experimental results reveal that an average of 94.06% in accuracy is obtained for the proposed methodology.

Keywords:
Skin texture, Skin detection, face recognition, Neural Networks, Fuzzy logic

1. Introduction

Facial Skin detection is one of the methods used in biometrics for the identification of any given facial images using the features present in the human face[1]. It is a tedious process to develop a computational model for the face skin detection for the process of face recognition. Proposing a computer based system for detecting the skin present in the human face is a tedious process. The process of detecting the skin present in human face has several difficulties such as: similarity between different skin texture; dealing with large amount of human faces and its skins, various expressions and hair present in the face etc. A good skin detection system must be robust and it should also overcome these difficulties. In general, a skin detection system comprises of many processing stages such as the noise detection; skin feature extraction; and skin recognition. The detection process of skin varies due to the texture caused by skin wrinkle. Due to the age factor, the skin texture changes which causes difficulty in its detection process. The objective of skin image analysis is that should be applied to various surfaces of skin with irregular non-periodic patterns. Fuzzy logic is one of the foremost techniques that contains of the mathematical framework to resolve the improbability of data [3]. Fuzzy logic is used for various types of skin images, their detection, and other process in the skin.

Fuzzy classifier is based on the fuzzy rules which can be used for the classification of the pixels of skin and the non-skin. Hence, various algorithms [4-7] based on fuzzy is proposed by earlier researchers such as the fuzzy logic based skin detection and classification, fuzzy interference system, modified Fuzzy C Mean algorithm, and Linear Matrix Difference (etc. In past few decades, methods based on ANN were used largely for proposing intelligent computer based systems which are related to the pattern recognition and image processing [8-11]. Many methods related to the facial skin recognition system such as: Geometrical features based; Template matching based; Graph matching based; and ANN approaches [6, 12-15]. Different ANN models were used widely in face recognition and many times they used in combination with the above mentioned methods. ANN simulates the way neurons work in the human brain. This is the main reason for its role in face recognition. Many researches adopted different ANN models for face recognition with different recognition rates and mean square error (MSE). Therefore, there is a need to identify the ANN model for face recognition systems with best recognition results. The objective of this research is to develop a face recognition system based on using four different ANN models: Feed Forward Backpropagation neural network (FFBPNN), Cascade Forward Backpropagation Neural Network (CFBPNN), Function Fitting Network (FitNet), and Pattern recognition Network (PatternNet). Each one of these models was constructed separately with 7 layers (input, 5 hidden layers and output layer) architectures. Each model was trained separately with six different training algorithms.

The paper is summarized as follows. Section 1 depicts the detailed description of fuzzy logic and texture of the human skin and the related works done in skin detection and its analysis. Section 2 explains of the proposed methodology for skin detection using the fuzzy logic and Section 3 consist of the experimental results and section 4

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depicts the conclusion and future enhancements of the proposed work.

2. Proposed Methodology

In this method, the input facial image is given towards the skin detection system. The input images are processed by filtering for the process of sharpening it. Filtering is a process that removes the impurities and noise from the given image. Filtering technique is used in order to remove the impurities completely so that a clear image texture can be obtained. For this process, a median filter is used. Then, the pixels of the different types of facial grey scale images are calculated. This is then followed by a black and white conversion within which the colour image is converted to a black and white image. If the input image is already a grey scale image, then the conversion will not affect the image. Algorithm for changing the colour image in to gray scale is shown in section 3.1. The converted pixels are further compared with the original grey scale image based on the fuzzy rules. This process is done for the first pixel to the last pixel so that all the pixels which are present in the entire image can be included in the overall process. This is then followed by the pixel matching algorithm, to seek out the similarity between the skin textures. The closest pixels were clustered based on the similarity between their pixels. The similar pixels were then clustered and arranged using the fuzzy logic. Finally, the FFBPNN is trained and tested for its accuracy of the skin detection. Overall architecture of the proposed methodology is shown in figure 1.

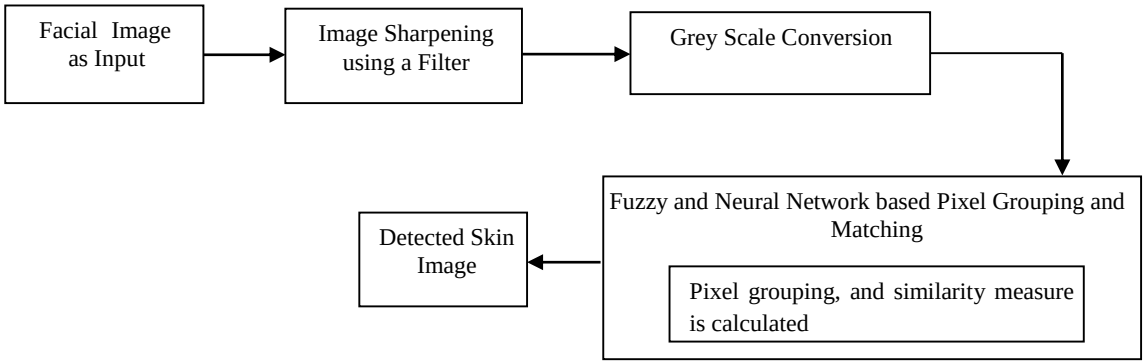

Fig. 1 Overall architecture of the proposed method

3. Implementation of the Proposed Methodology

3.1. Image Sharpening

Filtering may be a part of image sharpening that is employed to boost the overall details including the edges present within the image that are relevant to the usage. Additionally, filtering can even be used to eliminate the unwanted components of noise. Medical pictures sometimes contain salt and pepper noise. These noises are there because of the presence of minute grey scale variation within the image. Median filtering is a successful technique used image sharpening and also for removing the impulse noise[12]. Median filter is a commonly used method. It provides the exact noise-reduction skills, with essentially less blurring than other linear smoothing filters. Here, the median method was performed by considering a 3×3 windowing operator over the entire image[11].

3.2. Grey scale conversion

The proposed methodology works on black and white image since it is based on black and white pixels and its matching. For this process, the sharpened image is given as input towards the black and white conversion algorithm [2]. The filtered image can be further converted in to black and white image for the further process.

3.3. Artificial Neural Networks

The NN used in this method consists of many layers. First layer the input layer is which is used to receive the ANN inputs. Inputs as fuzzy rules are given towards the input layer. The remaining layers have connections from preceding layer. The last layer is responsible for generating output. Equation used to train the NN is as follows:

$$U_k(t) = \sum_{j=1}^{n} W_{jk}.x_j(t) + b_k(t) \quad (1)$$

$$Y_k(t) = \mu(U_k(t)) \quad (2)$$

Where,
$x_j(t)$ is the input value of j at time-step t,
$W_{jk}(t)$ is the weight assigned by neuron k to input j at time t,
μ is the nonlinear activation function,
$b_k(t)$ is the bias of k-neuron at time t, and
$Y_k(t)$ is output from neuron k at time t.

The process is repeated for the entire image so that an output vector $Y_k(t)$ can be obtained. The training process has weight adjustments in order to reduce the error. Procedure required to train the ANN model for the proposed algorithm is as follows:

1) Initialize the ANN model
2) Initialize learning rate, momentum variable and threshold error
3) Initialize 15 classes: class for each person. Each class contains 1 face images of one each person.
4) Classification process: Initialize 15 target vectors one vector for each face class: vector = t1, t2… t15.
5) Initialize the target output vector for each input vector of the 15 face images.
6) Apply steps of the training algorithm to train the ANN model.

3.4. Fuzzy and Neural Network based Pixel Grouping and Matching

In this work, a completely unique approach of mixing the Fuzzy logic and Pixel grouping and Matching algorithmic rule is developed. Fuzzy based Image Analysis could be a form of many-valued logic; it manages thinking that's inexact rather than matured and corrects[6]. Fuzzy logic could be a kind of multivalent reason during which the reality values of variables are outlined as any complex quantity between zero and one. The Fuzzy management Systems are a development of a logic that permit for terribly precise management of robotic systems. The Fuzzy set is that the foundation of an instability hypothesis associated a device for each linguistics and numerical framework. In this work, the image is scanned from the first pixel to the last pixel. Initially, the set of six pixels are taking in to consideration. Here, the fuzzy rules are applied to check whether the pixel is a grey or black. Since the image is converted in to grey scale, it has only black and grey pixels. If the pixel is black, then skip the first set of six pixels and go to the seventh pixel. If the pixel is grey, group all the pixels in to one and change it to white. Repeat the above process until all the complete pixels are readed and changed. The proposed algorithm for Fuzzy based pixel grouping and matching is shown below.

Algorithm for Fuzzy and Neural Network based Pixel Grouping and Matching

Step.1 Assign A_1 = twenty pixels,
Step.2 if A_1= black. Traverse towards twentieth pixel until white pixel appears.
Step.3 if A_1 = white
Step.4 Combine the pixels and change it to white
Step.5 Check the twenty first pixel
Step.6 Set A_2 = twenty first pixel
Step.7 if A_2 = black,
Step.8 Perform step 2
Step.9 Else, perform step 5
Step.10 Continue the process towards the entire image
Step.11 End

4. Experimental Results

The proposed algorithm for detecting the skin is implementation using Matlab programming. The face images which are taken from Oral face database is given as input to the skin detection system. The noise free image obtained by further filtering process is currently, modified in to gray scale mage using the black and white conversion method. This is then followed by the pixel matching algorithm, to seek out the similarity between the skin textures. The closest pixels were clustered based on the similarity between their pixels. The similar pixels were then clustered and arranged using the fuzzy logic. Finally, the FFBPNN is trained and tested for its accuracy of the skin detection. The metrics used for calculating the performance is shown in equation one, two and three respectively and the results obtained from these equation are shown in Table 1.

$$\text{Sensitivity} = \frac{TP}{TP+FN} \quad (3)$$

$$\text{Specificity} = \frac{TN}{TN+FP} \quad (4)$$

$$\text{Accuracy} = \frac{TP+TN}{TP+FN+TN+FP} \quad (5)$$

Where, TP is the True Positive which is the number of pixels which represents the non-skin, FP is the False Positive which is that the number of skin pixels identified as non-skin pixels, TN True Negative is the number of skin pixels marked as skin pixels and FN False Negative is the number of non-skin pixels marked as skin pixels. The Specificity, Sensitivity and Accuracy of the image are calculated. Table 1 shows the performance analysis based on the three metrics.

Table 1: Specificity, Sensitivity and Accuracy of the proposed methodology for different Images

Image	Sensitivity (%)	Specificity (%)	Accuracy (%)
Image 1	95.18%	92.26%	94.61%
Image 2	98.82%	92.19%	95.72%
Image 3	95.14%	90.62%	92.81%
Image 4	97.47%	92.41%	94.55%
Image 5	97.35%	92.81%	93.82%
Average	96.94%	91.34%	93.16%

Figure 3 shows the Sample images of 15 different facial images taken from Oral face database for the process of training the NN.

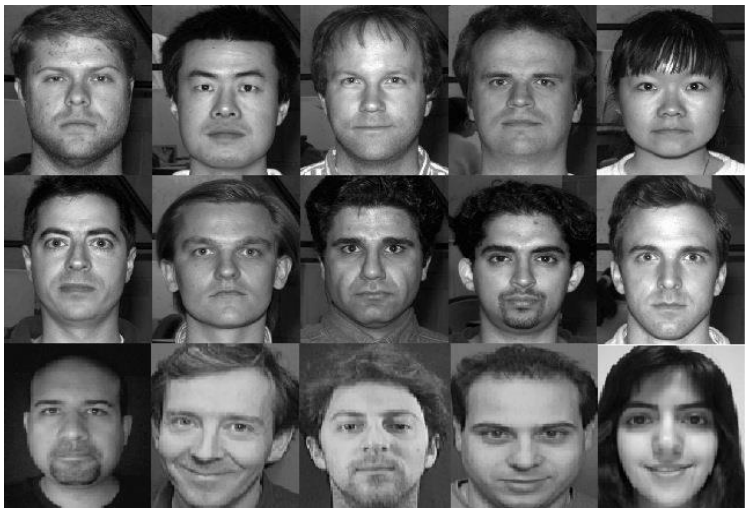

Fig. 2 Samples from Oral face database for 15 persons.

Fig. 3 Outputs of the facial skin detection from the proposed algorithm

5. Conclusion

In this paper, a novel method for detecting the skin by combining the fuzzy logic and Neural Network is proposed. Initially, the pixels of the complete image are transferred in to grey scale images. Secondly based on the fuzzy rules, the computed pixels are compared with the original grey scale image. This process is done for the entire image so that all the pixels present in the entire image can be included in the overall process. Finally, the FFBPNN is trained and tested for its accuracy of the face detection. The proposed system is done based on Artificial Neural Network (ANN) method called as the Feed Forward Back Propagation Neural Network (FFBPNN). The ANN model is constructed with 7 layers input layer, 5 hidden layers each with 15 hidden units and an output layer. Experimental results shows higher for the proposed method of identifying the skin. Future enhancements in this work are to propose an efficient algorithm to detect the facial images of group of faces present in a single image.

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