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A Neural Network Approach to Gender Classification using Facial Images

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ABSTRACT
Plastic Gender classification is an important task in today's technological world with a variety of applications such as commercial profiling, surveillance purposes, monitoring applications, and human-computer interaction. In this paper, an approach for developing an automatic system to classify gender from an facial image using Neural Network Classifier is presented. Feed forward back propagation neural network is trained to classify the given image as male or female. The given image is first preprocessed using facial color segmentation and only the face part is fitted in minimum bounding rectangle. The preprocessed image is then enhanced by applying histogram equalization, smoothening and sharpening and is then allowed to feed as input to the neural network. The experiments are performed on Indian Face Database, MIT-CBCL database and FEI database and the accuracy of the system is computed for these databases. It is found that training time with this approach is considerably reduced, and the system accuracy varying between 90 to 92%.

Keywords **-** Gender classification, frontal facial images, Neural Network approach, back propagation algorithm, preprocessing.

I. INTRODUCTION

Gender classification is an important task in today s technological world with a variety of applications such as commercial profiling, surveillance purposes, monitoring applications, and human-computer interaction. Gender classification can also be used as a filtering mechanism to enhance performance of face recognition both in terms of speed and accuracy.

So far, different methods have been proposed for gender classification using gait [2], iris [3], and hand shape [4]. However, the majority of studies on gender classification are based on face information. A comparison study of different gender classification approaches using face information can be found in [5]. Recently, the problem of sex classification was studied on the faces with arbitrary viewpoints and under occlusion [6].

Most of these methods for gender classification are based on training processes using several samples for each person. They include Support Vector Machines, Neural Networks, and Principal Component Analysis [7]. Preparing multiple training image samples from different point of views or under different lightening conditions is usually difficult or even impossible.

There is a trend towards single image per person face recognition and understanding.

Previous studies for facial gender classification can be classified into two categories [7]: *geometric-based* and *appearance-based*. In the former category, the distance between different points in the facial image is used, while the latter category is based on the pixel-values of the face image. Each of these approaches has its own advantages and disadvantages. Methods of the appearance-base category can be considered holistic, in which the feature vector is extracted from the whole face image. Such a representation has the advantage over geometric-based category that information is extracted from all regions of the face. A disadvantage of the holistic appearance-based representation, however, is its sensitivity to local appearance variations, which can be caused by variability in position, pose, expression and illumination. Solution to this problem, which we proposed in this paper, is to use general faces obtained by averaging over facial images of the same sex in the database. Comparing the input image to the male and female general images can considerably reduce local appearance variations.

This paper is based on the work done by the authors in the paper," What's the difference between men and women? Evidence from facial measurement"[14][27]. but, some necessary modifications are there in our paper, which were beneficial to reduce the time required by the system.

The actual difference between the two is that, we have added the pre-processing step, before actual data feeding to the neural network, thereby training time required by the network get reduced and accuracy got increased. In pre-processing, the images are cropped by fitting rectangle on the frontal faces using facial color segmentation algorithm[8][9], image qualities are enhanced using histogram equalization. And the resulting images are then allowed to feed as input to the neural network.

II. THE PROPOSED GENDER ESTIMATION METHOD

To be compatible with a single image per person, the proposed system uses a training procedure for gender estimation. Before building the classifier and training the neural network, the initial steps are to prepare the database,
pre-process the data by fitting rectangle on to the frontal face and enhance the image quality. So the steps are:

A. Data Preparation:

Data used in this paper is a combination of three databases 1.Indian Face Database[24] 2.MIT-CBCL Database[25] 3.FEI Face Database[23]. These databases contains human face images. All images are in JPEG color format. The size of images are different for different database. There are images of males and females, together we get 300 images in all. And, we can say that this paper is not based on single database and size of the image will not affect the processing of the proposed system.

Every database contains images of different poses for each individual. But, we require only neutral pose images as we are not working on their emotions or expressions like smile, laughter, sadness or etc. So, only neutral images are used from these databases.

B. Pre-processing the image:

In this module, we preprocess the image by fitting minimum bounded rectangle on to the face part and thereby we subtract the background from the image. To accomplish this we are using an algorithm which is based on color of face. In this algorithm, first we get the mean value for red, green and blue values of facial portion. And this mean value is then compared with red, green and blue values of every pixel of image from center to rightward, downward, leftward and upward direction. For comparison, we are using squared Euclidian distance 2700 as threshold, called as Just Noticeable difference[8]. That is if distance of red, green and blue values exceed this threshold, we get the pixel which is not of facial part. By finding such four pixels in each direction, we get the rectangle that hold only face part of the image.

Preprocessing the image: Fitting rectangle on frontal face using Facial color image segmentation [9].

Algorithm:

Input: Facial Image Output: Fitted minimum bounded rectangle on frontal face.
Concept: Use of facial color

Steps: Step 1. Find out central 40% area of the image.
Step 2.Calculate mean value for red, green and blue values of each pixel of that 40% central area.(say Ra, Ga, and Ba)
Step 3. Use this mean value as an average face color. Now, move towards upward, downward, leftward and rightward pixel by pixel, and compare R, G and B values of every pixel with the Ra, Ga, and Ba.

For comparison, we use squared Euclidean distance 2700[8] as a threshold value. And use the formula

If ((R-Ra)^2 + (G-Ga)^2 + (B-Ba)^2) >2700

We get one pixel in each direction, which could be considered as a pixel of that minimum bounded rectangle.

Step 4. Now, use these four pixels of each direction to plot minimum bounded rectangle.

Once we get the frontal face part by eliminating the background and other hints of the correct sex due to clothes and hair information, the images are then enhanced using histogram equalization, smoothening and sharpening methods. The block diagram pre-processing the images is shown in the fig.1.

Enhanced image is then, quantized to the 30*30 pixels 256 gray levels. and, thus now we get pre-processed and quantized database, this database now can be fed as input to the neural network. More than half database is used for training purpose, while the remaining is used for testing purpose. The block diagram of the System is shown in the fig.2.

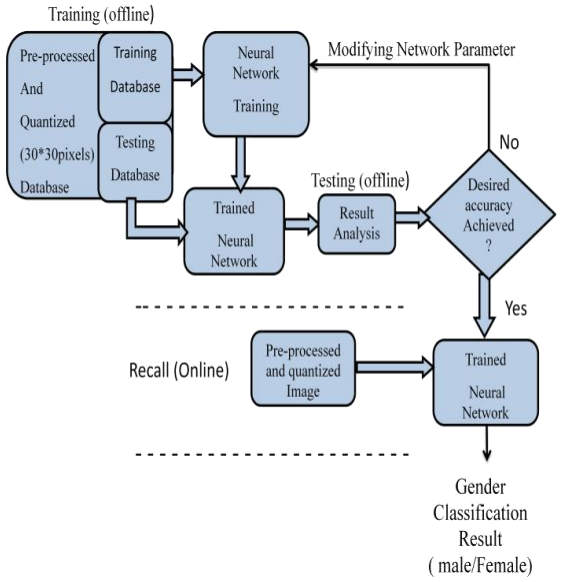

Fig. 1 Block Diagram for Pre-Processing

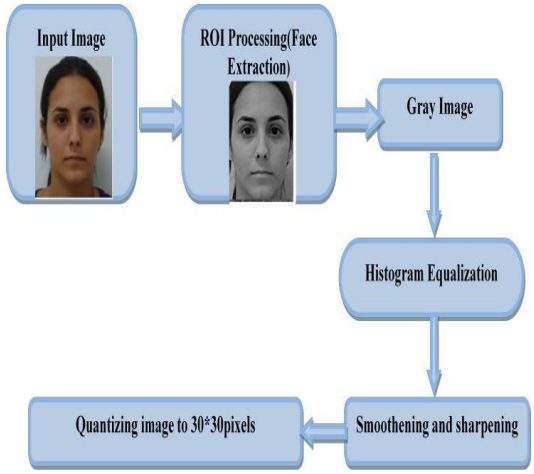

Fig. 2 Block diagram of Gender Classification System for Training and Testing and recall

III. DESIGN OF NEURAL NETWORK CLASSIFIER

A. Classification

- For classification we are using a Neural Network Classifier (NN Classifier).
- The Neural Network Classifier is constructed using MATLAB software and consists of 900 input neurons, 10 hidden layer neurons and 1 output neuron (900*10*1).
- The output neuron is 1 for female and 0 for male.
- The goal is set to 0 to get maximum performance.

B. Training the Neural Network Classifier.

- The NN Classifier is then trained using the training data which contains 100 males and 100 females.
- The training is done for 1000 epochs using back propagation algorithm.

C. *Testing the Neural Network Classifier using Testing Data.*

Once the classifier is trained, it is tested using testing data, here we have used 50 females and 50 males for testing purpose. The testing data is similar to training data only difference being that it is not used while training the NN. So, the testing data should be new to the NN classifier to test it correctly.

Fig.3 shows the actual design of our neural network, while fig 4.is the view of our network, and fig.5 is the snapshot generated during the training neural network using back propagation algorithm.

Fig. 3 Design Neural Network Classifier

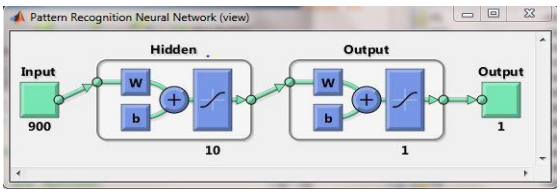

Fig. 4 view of Network

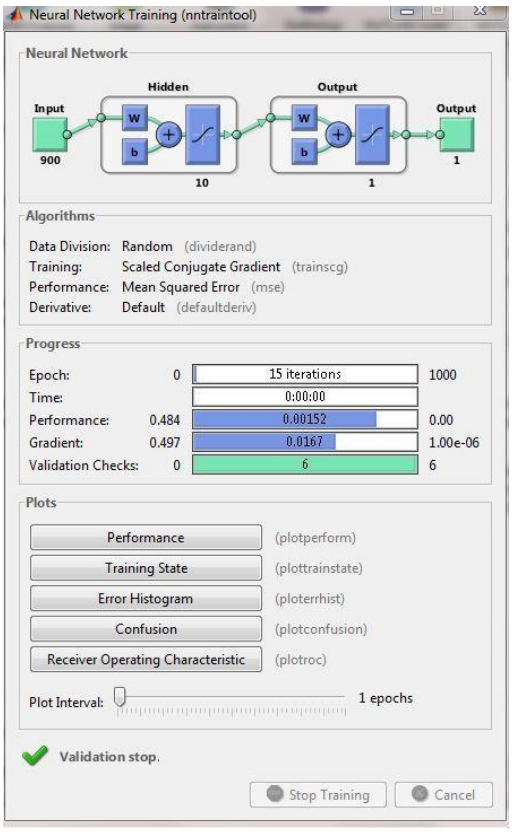

Fig. 5 Neural Network Training

IV. EXPERIMENTAL RESULTS

In this paper, we are using MATLAB environment to implement it, on i5 processor with the RAM of 4GB. To evaluate the proposed method, we used three facial databases: Indian Face Database, FEI Database[23] and MIT CBCL database Indian Face database consists of different facial images of 22 female and 40 male persons (total 62 persons) [24]. However in this paper, we only used neutral (frontal facial image without any expression) images of Indian face database. We also built an FEI database (with the same distribution as Indian database) consists of facial images of Brazilian persons. In this database the numbers of male and female subjects are exactly the same and are equal to 95. Thus, we got 190 images from FEI database, and the remaining 48 images are taken from MIT-CBCL database [25].

Experiments are carried on all the three databases, first on individual databases and then on combination of all the three databases. The results are shown in the following tables.

TABLE I: Testing Results On Trained Data On Indian Face Database

Trained data	Total number	Correctly classified	Incorrectly classified	Accuracy
Male	20	20	0	100%
Female	20	20	0	100%
Total	40	40	0	100%

Table Iii: Testing Results On Untrained Data On Indian Face Database

Trained data	Total number	Correctly classified	Incorrectly classified	Accuracy
Male	12	11	01	91.66%
Female	10	9	01	90%
Total	22	20	2	90.9%

Table IIIII: Testing Results on Trained Data on Fei Database

Trained data	Total number	Correctly classified	Incorrectly Classified	Accuracy
Male	75	75	0	100%
Female	75	75	0	100%
Total	150	150	0	100%

TABLE IVV: Testing Results on Untrained Data on Fei Database

Trained data	Total number	Correctly classified	Incorrectly Classified	Accuracy
Male	15	12	03	80%
Female	25	25	0	100%
Total	40	37	03	90%

TABLE V: Testing Results On Trained Data On Combination Of All Three Databases.

Trained data	Total number	Correctly classified	Incorrectly classified	Accuracy
Male	100	100	0	100%
Female	100	100	0	100%
Total	200	200	0	100%

TABLE VI Testing Results On Untrained Data On Combination Of All Three Databases.

Trained data	Total number	Correctly classified	Incorrectly classified	Accuracy
Male	50	43	07	86%
Female	50	48	02	96%
Total	100	91	09	91%

Time required is also an important constraint for any system to work along with accuracy, so the observations regarding time constraints are

- Time required to Pre-process an Image- 2.186818 seconds to 2.976854 seconds.
- Time required to Train Neural Network using - 1.985930 seconds to 2.397796 seconds.
- Time required to classify an image, whether it is male or female is- 0.862286 seconds to 1.536411 seconds.

- But the training time required is not an online process, that is, when we actually classify the images, we already have trained network with us, so at the time of classifying any image, we have to only pre-process it and then we can classify it.
- So, the total average time required by the system- Pre-process time + Classification Time.
- Total Average Time = 3.78118 seconds.

Data Samples

Fig. 6 Images of FEI database

Fig.7 Pre-processed Images before feeding to the Neural Network

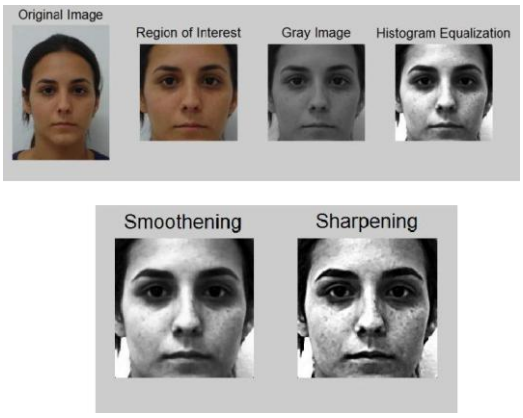

Fig. 8 Pre- processed Images

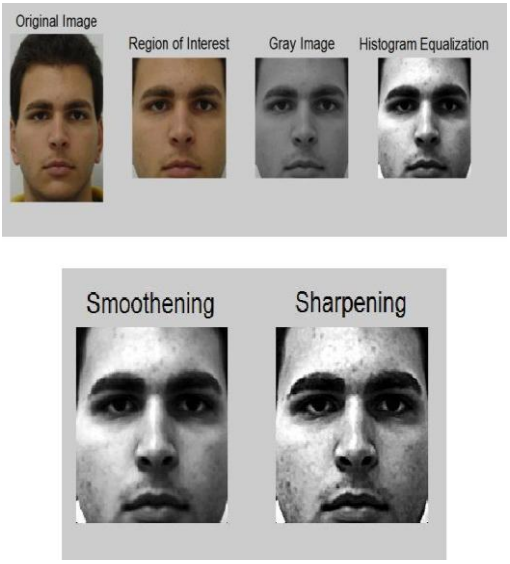

Fig. 9 Pre- processed Images

V. CONCLUSIONS

In this paper, a neural network approach to the Gender Classification using facial images is successfully implemented. The accuracy of the system is quite good and is evaluated over different databases. From the experimental results it is noticed that, accuracy increases as we increase training data set. As with 300 images accuracy varies between 90 to 92%, it can improved by increasing the number of training images. The novelty of this system is that, it doesn□ t require feature extraction step, which is computationally intensive process. Instead we have sampled the training images to lower resolution after pre-processing and thereby saved much of the time. The results are encouraging and in future we would train the neural network with more number of images to improve the classification accuracy.

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