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Low Resolution Single Neural Network Based Face Recognition

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***Abstract*—**This research paper deals with the implementation of face recognition using neural network (recognition classifier) on low-resolution images. The proposed system contains two parts, preprocessing and face classification. The preprocessing part converts original images into blurry image using average filter and equalizes the histogram of those image (lighting normalization). The bi-cubic interpolation function is applied onto equalized image to get resized image. The resized image is actually low-resolution image providing faster processing for training and testing. The preprocessed image becomes the input to neural network classifier, which uses back-propagation algorithm to recognize the familiar faces. The crux of proposed algorithm is its beauty to use single neural network as classifier, which produces straightforward approach towards face recognition. The single neural network consists of three layers with Log sigmoid, Hyperbolic tangent sigmoid and Linear transfer function respectively. The training function, which is incorporated in our work, is Gradient descent with momentum (adaptive learning rate) back propagation.

The proposed algorithm was trained on ORL (Olivetti Research Laboratory) database with 5 training images. The empirical results provide the accuracy of 94.50%, 93.00% and 90.25% for 20, 30 and 40 subjects respectively, with time delay of 0.0934 sec per image.

***Keywords*—**Average filtering, Bicubic Interpolation, Neurons, vectorization.

I. Introduction

THE way of matching faces with the stored set of images (database) is known as face recognition. The lengthy tenure of success and achievements has blessed human nervous system with abilities that are absent in basic computing or even in modern parallel computing e.g. highly interconnection, adaptive nature, learning skills and generalization etc. In present or in coming times systems based upon biological neurons contain some of such characteristics [1].

Human brain has numerous highly interconnected biological neurons, which on some specific tasks can perform faster than super computers. Humans start recognizing faces as they start growing up but for computers it's a cumbersome task. So idea is to a imitate computer system which recognize faces as human brain does. Neural Networks has been widely used in pattern recognition applications and it has performed effectively in face recognition paradigm [2]. The most part of our research has been spending upon deciding the robust architecture of neural network (sequence of transfer functions). Biological neurons based human recognition of faces uses data from various senses and all that data is stored and remembered for faces. Similarly in case of computers artificial neurons are used to idealize the biological neurons [3].

Problem of recognizing faces is basically a classification problem. The proposed technique uses artificial neurons in order to train the classifier. Problem is further researched with the dimensionality reduction preprocessing. In recent times back propagation neural network system implemented make use of fractal encoding method, the fractal codes are presented as input to the back propagation neural network for identification purposes. The system was tested upon ORL database. The performance was reported as 85% correct recognition rate [7].

Face recognition methods mainly fall into feature based and image based/holistic categories, feature based techniques have emphasis on measuring e.g. distance between eyes, Eye socket depth, cheekbones, width of nose and chin etc, based upon these measured features it makes face representations. Whereas in image-based techniques global image representations are taken into account for recognition purposes e.g. Principal Component Analysis (PCA) and Neural Network technique constitutes image based recognition.

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II. Proposed Technique

This work deals with recognition faces using low resolution images through Neural Networks. Carrying out the same task with higher dimension can cause overfitting and computational complexity. Data in high dimensions contain redundancies and irrelevant parameters, neural networks require large networks to cope up training of such data [4]. In the proposed technique, image resizing is applied to get an edge in terms of time and memory utilization over the high resolution images.

In order to accomplish face recognition task just single neural network is incorporated. Implementation is divided into two phases. The pre-processing phase and the Neural processing phase. In Pre-processing phase time effective pre-processing is performed in order to make image data best fit for neural network input. This phase output images of low resolution, which have the information required for recognition. Neural network further got two steps training and testing, in training neural network learns through examples,

training set of images is presented as input, each layer output is calculated through transfer functions acting as summation junction, and it uses back propagation algorithm to accomplish recognition training part to achieve desired results. In testing each image in database is tested and recognition rate is calculated.

III. Preprocessing Phase

Average filtering is applied and contrast of the image is enhanced through histogram equalization process. Then image size is reduced in order to make it light but efficient and best fit for neural processing phase. Before handling, images to neural processing all the images data undergoes process of vectorization discussed in upcoming section. Hence instead of heavy pre-processing computationally light methods are applied as pre-processing. The flow diagram shown in Fig 1, gives complete overview of training flow for the implemented technique.

A. Average Filtering

After retrieving images from the database, each image undertakes smoothing process. The mean/averaging filter is applied in order to produce the blurry effect, because in the later stages algorithm include step of resization (down sampling) while maintaining the quality of face image. The 5*5 filter is used for this process, as shown in Fig. 2.

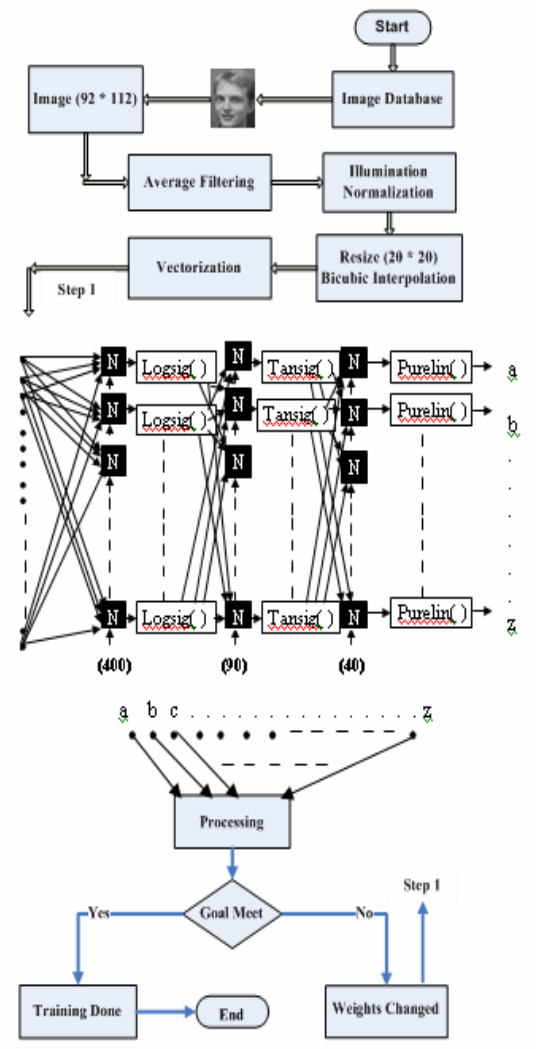

Fig. 1 Flow Diagram of Neural Network Training

1 / 25	1 / 25	1 / 25	1 / 25	1 / 25
1 / 25	1 / 25	1 / 25	1 / 25	1 / 25
1 / 25	1 / 25	1 / 25	1 / 25	1 / 25
1 / 25	1 / 25	1 / 25	1 / 25	1 / 25
1 / 25	1 / 25	1 / 25	1 / 25	1 / 25

Fig. 2 5*5 Mean Filter

$$R = \frac{1}{25}\sum_{i=1}^{25} z_i \quad (1)$$

Equation (1) calculates the average value of the pixels, whereas 'z' is the mask, 'i' are mask elements. The output 'R' is then convolved with image to produce filtering effect, for a 5*5 mask used in the implementation it will be comprising average of 25 pixels in that box filter.

B. Histogram Equalization

After being processed from averaging filter all images undertakes process of histogram equalization. This equalization process is done in order have uniform distribution of intensities and to enhance contrast of the images. Mathematically histogram equalization can be expressed as:

$$s_k = T(r_k) = \sum_{j=0}^{k} \frac{n_j}{n} \quad (2)$$

Whereas k=0,1,2,...,L–1

Here in equation (2) 'n' is the total number of pixels in an image, 'n_j' is the number of pixels that have gray level 'r_k' ,and 'L' is the total number of possible gray levels in the image. The process of histogram equalization is shown in Fig. 3.

Original Image Histogram Equalized Image

Fig. 3 Histogram Equalization

C. Bi-Cubic Interpolation

The process of histogram equalization is followed by image resization process. The key advantage of resizing through bicublic interpolation is that it produces more smoother surfaces than any other interpolation technique. Reducing the actual resolution of the image [5], e.g. 92 * 112 to 20 * 20. Bicubic Interpolation takes into account 16 pixels in the rectangular grid, takes weighted average of pixels and replace them with a single pixel, that pixel has actually got the flavor of all the replaced pixels.

This reduction is done to reduce redundant information and to make neural network input data low dimensional, because of the fact that input layer of Neural network require the same number of neurons as number of pixels in an input image. In this way, less number of input neurons makes it less complex and easy for neural network training and testing phases. Here the actual resolution of an image is reduced also to ease complexity in convergence and significant effects on time required for training the neural network.

D. Vectorization and Targets Creation

Vectorization is the process of transforming image data in the form of vectors. The 2 dimensional image is vectorized to form 1dimensional vector as neural network requires 1D vector for processing. Hence all the images are contained in a matrix, in this way in that matrix a column represents an image's whole data.

The research work is based upon *supervised learning* rule in which targets are provided before to the neural network in order to make suitable adjustments of weights to achieve the desired output while training. The outputs neurons are told in advance what there response should have to be, whereas the method used for error convergence is Least Mean Square (LMS). Target vector matrix is constructed before handing over the images as input to the Neural Network.

IV. Neural Network

A. Training and Transfer Functions

The architecture of the proposed single neural network is a based upon multi layers, it uses three layers, input, hidden and output layer. Pre-processed images in the vector format are presented as input to the neural network which contains 400 neurons in the input layer, hidden or processing layer of this network contains 90 neurons, the number of neurons in hidden layer comes from experience and guess work considering optimal performance. Finally, output layer contains the neurons equal to the number of subjects under consideration. Algorithm make efficient use of single neural network and minimizes the gradient of the error through adjusting weights and biases continuously with momentum. Momentum acts like a low pass filter and ignores small features in error surface so that network do not stuck into a shallow local minimum.

Neural Network is trained upon some set of images, and tested upon unseen images. In proposed technique neural network uses back propagation algorithm for error computation and new weights calculation for each neuron link. The network undergoes process of training, continuously in an iterative manner it calculates output from each layer, extracting the mean square error and propagating it backwards if it is not approaching targets. Due to this backward error propagation, error-signal for each neuron is calculated. Which in fact is used for neuron weight updation. If its approaching targets then training is considered done. It has been observed that as the number of subjects increases, the training time also increases (as the complexity of the input increases with the increase in the number of face images (subject classes)). In this way network approaches the set known correct outputs (targets) in order to be trained. The process of training is shown in Fig. 4, in which training curve is approaching its goal through readjustment of weights and biases.

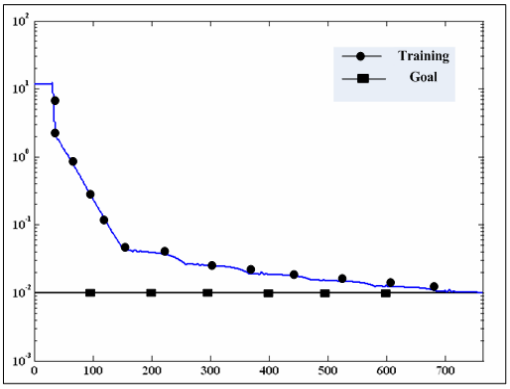

Fig. 4 Training Graph

The response of the Neural Network is dependant upon weights, biases and transfer functions. The transfer functions used in the feed-forward back propagation neural network are purelin( ), tansig( ), logsig( ). These functions acts as summation junction and calculates the output from the inputs presented.

B. Testing

Images for testing applied to the trained neural network along with already trained images for calculating the percentage of accuracy and error.

In testing, like training incoming images undergoes through all the pre-processing and make available to the network for simulation. Simulation is the process in which network object, image data is presented as inputs, and it simulates the network. After checking, each image in the database correct counter along with error counters are incremented.

V. Results and Discussion

The algorithm is implemented using 2.4 GHZ Pentium 4 machine with Windows XP and MATLAB 7.0 as the development tool.

The ORL database has 40 subjects with 10 images per person. Two set of images are required, one for the training of the neural network and another set of images upon which testing is done. In this research technique each subject's out of 10 images picked 5 images as training examples and 5 images as testing set for the neural network. After the training session, the trained network is tested upon the unseen images and also upon which training has been done.

In first case, 20 subjects (200 images) are taken as input, and after multiple iterations of neural network training, in testing deduced 94.5% results. Similarly for 30 subjects (300 images) and for 40 subjects (400 images) its giving 93% and 90.25% results respectively as shown in table I. Whereas LR-SNN-T, Low Resolution Single Neural Network Technique denotes the implemented technique.

TABLE I
Recognition Rates

No. of Subjects	Percentage of Recognition (LR-SNN-T)
20 (200 images)	94.5%
30 (300 images)	93%
40 (400 images)	90.25%

It is clearly seen as the number of subjects increases performance decreases a bit, whereas considering the fact that this technique produced high percentage of results without using any heavy pre-processing technique.

In the graph displayed in Fig. 5, research work conducted results are compared with other implemented techniques including previous implementation of Back propagation neural network Technique. Here the number of subjects is plotted against percentage correct detections, rate of recognition is high initially but it keeps on deteriorating as the complexity increase. Here it is clearly seen that the performance of the implemented algorithm LR-SNN-T (Low Resolution-Single Neural Network-Technique) is better than the others mainly because of its time effective pre-processing, fine-tuning of neural network neurons and right combination of transfer functions along with suitable training function.

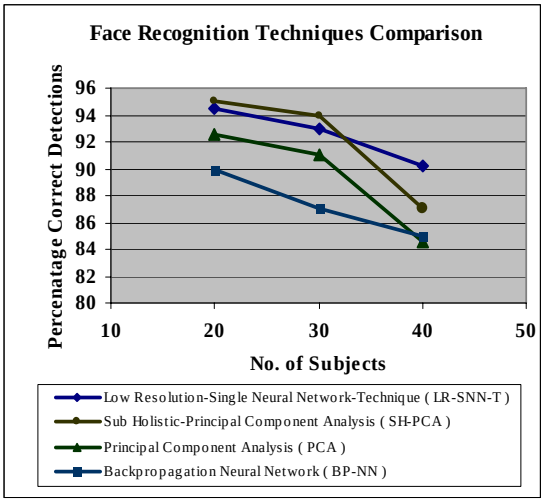

Fig. 5 Techniques Comparison Graph

Testing time comparison of different techniques is provided in Table II. The proposed technique (LR-SNN-T) shows effective testing time as compared against Hybrid Sub-Holistic & Holistic Technique (H-SHH-T) [8], scale invariant algorithm [9] whereas Principal Component Analysis (PCA) [6] performs better time-wise but not recognition wise.

TABLE II
TESTING TIME COMPARISON

Testing Time	200 images	300 images	400 images
PCA	3.8 s	5.7	8.12 s
H-SHH-T	73 s	153 s	266 s
LR-SNN-T	18.68 s	28.23 s	38.12 s
Scale invariant	22.30 s	33.45 s	44.61 s

VI. CONCLUSION AND FUTURE WORK

Face Recognition is basically a classification problem. In the research work neural network using backpropagation has been trained as a face classifier to recognize faces with time effective pre-processing, which greatly increases the performance of the network. By lowering the resolution and using Single Neural Network for whole recognition task, computational complexity has been reduced many times.

As a future prospect, we deploy a heavy pre-processing to the input data and multiple neural networks will be used so that performance can be enhanced and produce significant results but then it will be a tradeoff among time, memory and performance.

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