Comparative Study of Neural Networks for Face Recognition

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1. Introduction to Neural Networks

Neural Networks are the networks of simple neural processors, arranged and interconnected in parallel. Neural Networks are based on our current level of knowledge of the human brain, and attract interest from both engineers, who can use Neural Networks to solve a wide range of problems, and scientists who can use them to help further our understanding of the human brain. Since the early stages of development in the 1970's, interest in neural networks has spread through many fields, due to the **speed of processing** and ability to **solve complex problems.**

As with all techniques though, there are **limitations.** They can be **slow** for **complex problems**, and can be too dependent on the training set used, but these effects can be minimized through careful design.

Neural Networks can be used to construct systems that are able to classify data into a given set or class. **Figure 1** shows an example of a single neural processor, or neuron. Neurons have many weighted inputs; say each input (p1, p2, p3… pm) has a related weight (w1, w2, w3… wm). Each of these inputs is a scalar, representing the data. In the case of face detection, the shade of GRAY of each pixel could be presented to the neuron in parallel (thus for a 10x10 pixel image, there would be 100 input lines p1 to p100, with respective weightings w1 to w100, corresponding to the 100 pixels in the input image). The weighted inputs are combined together, and if present, a bias (b) is added.

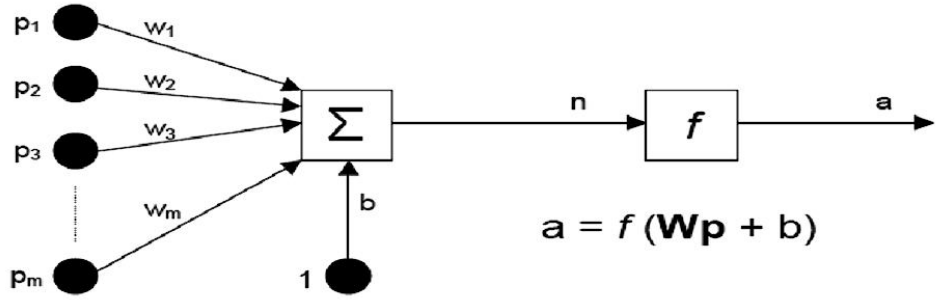

Figure 1: **A Single Neuron Neural Network**

This is then passed as the argument to a transfer function (typically a pure linear, hard limit, or sigmoid function), which outputs a value (a) representing the chosen classification.

2. Introduction to Face Recognition

The way of matching faces with the stored set of images (database) is known as face recognition. Face recognition means to identify the correct face from its physical measurements. Physical characteristics of the face are considered which could be distance between eyes and nose etc. Face

Recognition may seem an easy task for humans, and yet computerized face recognition system still can not achieve a completely reliable performance. The difficulties arise due to large variation in facial appearance, head size, orientation and change in environment conditions. Such difficulties make face recognition one of the fundamental problems in pattern analyses. In recent years there has been a growing interest in machine recognition of faces due to potential commercial application such as film processing, law enforcement, person identification, access control systems, etc.

3. Applications of Face Recognition

3.1. Machine recognition of human faces is used in a variety of civilian and law enforcement applications that require reliable recognition of humans. Identity verification for physical access control in buildings or security areas is one of the most common face recognition applications.

3.2. To allow secure transactions through the Internet, face verification may be used instead of electronic means like passwords or PIN numbers, which can be easily stolen or forgotten. Such applications include secure transactions in e- & m-commerce and banking, computer network access, and personalized applications like e-health and e-learning.

3.3. Face recognition is also a crucial component of ubiquitous and pervasive computing, which aims at incorporating intelligence in our living environment and allowing humans to interact with machines in a natural way, just like people interact with each other. For example, a smart home should be able to recognize the owners, their family, friends and guests, remember their preferences (from favorite food and TV program to room temperature), understand what they are saying, where are they looking at, what each gesture, movement or expression means, and according to all these cues to be able to facilitate every-day life.

4. Types of Neural Networks

Artificial Neural networks are commonly classified into 2 groups as per the by arrangement of neurons and the connection patterns of the layers:

1. Feed Forward networks
2. Feedback networks

4.1. Feed Forward Networks

Feed-forward Neural networks (figure 2) allow signals to travel one way only; from input to output. There is no feedback (loops) i.e. the output of any layer does not affect that same layer. Feed-forward Artificial Neural Networks tend to be straight forward networks that associate inputs with outputs. They are extensively used in pattern recognition. This type of organization is also referred to as bottom-up or top-down

The feedforward neural networks consist of three or more layers of nodes: one input layer, one output layer and one or more hidden layers. The input vector x passed to the network is directly passed to the node activation output of input layer without any computation. One or more hidden layers of nodes between input and output layer provide additional computations. Then the output layer generates the mapping output vector z. Each of the hidden and output layer has a set of connections, with a corresponding strength-weight, between itself and each node of preceding layer. Such structure of a network is called a Multi-Layer Perceptron (MLP). Examples of feedforward networks are Error BackPropagation networks, Radial basis function networks, Probabilistic Neural Networks etc.

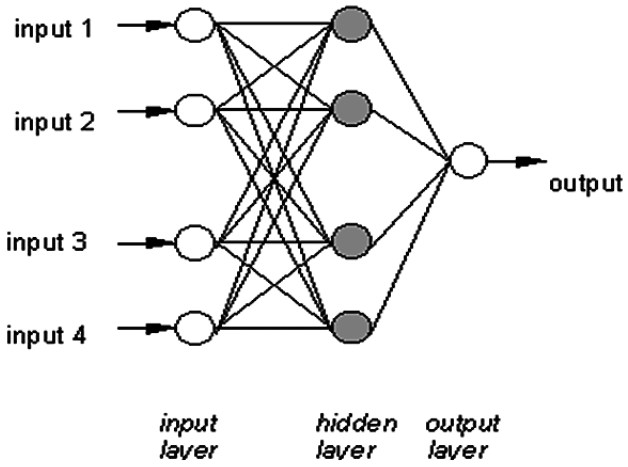

Figure 2: An example of a simple feedforward network

Error Backpropagation Networks

The error backpropagation network (EBP) is one of the most commonly used types of neural networks. The EBP networks are widely used because of their robustness, which allows them to be applied in a wide range of tasks. The error backpropagation is the way of using known input-output pairs of a target function to find the coefficients that make a certain mapping function approximate the target function as closely as possible.

Radial-Basis Function Networks

A Radial Basis Function (RBF) is another type of feed-forward ANN. Typically in an RBF network, there are three layers: one input, one hidden and one output layer. Unlike the backpropagation networks, the number of hidden layer can not be more than one. The hidden layer uses Gaussian transfer function instead of the sigmoid function. In RBF networks, one major

advantage is that if the number of input variables is not too high, then learning is much faster than other type of networks. However, the required number of the hidden units increases geometrically with the number of the input variables. It becomes practically impossible to use this network for a large number of input variables.

Probabilistic Neural Network

Probabilistic neural networks can be used for classification problems. When an input is presented, the first layer computes distances from the input vector to the training input vectors, and produces a vector whose elements indicate how close the input is to a training input. The second layer sums these contributions for each class of inputs to produce as its net output a vector of probabilities. Finally, a compete transfer function on the output of the second layer picks the maximum of these probabilities, and produces a 1 for that class and a 0 for the other classes.

5. Problem definition

I have taken the problem as 'Comparative study of neural networks for face recognition' as my thesis topic. The idea is to a imitate computer system which recognize faces using neural networks. The problem on hand is to identify the face whether it is correct one of the same person or of a different person. However, face recognition using computer vision is a difficult task. With an increasing emphasis on security, automated personal identification based on biometrics has been receiving extensive attention over the past decade.

Face recognition is becoming a very active topic in both research and practical applications. This is because face recognition system would find countless applications, e.g. Criminal identification and retrieval of missing children, workstation and building security, credit card verification etc.

Different neural networks are studied and their performance is evaluated, so that we can identify the best neural network for face recognition.

6. Objective of research work

The objective includes:

- To study the various neural networks for face recognition.
- Comparison and performance evaluation of the various neural networks (e.g. Back propagation Neural Network, Radial Basis Neural Network, Probabilistic Neural Network) that are commonly used for face recognition.

7. Implementation

Three different models of neural networks i.e. Back Propagation Neural Network, Radial Basis Neural Network and Probabilistic Neural Network are implemented in Matlab and their results have been compared. The classification is based on attributes extracted from human face images.

The attributes used for training are size of eyes, nose, mouth etc.

The face recognition system can be broken down into 4 main areas:

1. Image Database
2. Creation of network
3. Training of neural network
4. Testing of neural network

1. Image Database

The database used in this work has been extracted from Indian Face Database. Only frontal views of human faces are used for this work. The database consists of 50 face images .The size of face is 128 x 128 pixels. Five attributes are extracted from each face image in vector form and these vectors act as input to the neural network. The five attributes are size of left eye, size of right eye, size of nose, size of mouth and the distance between left and right eye.

Some of the face images are shown below.

Figure 3. Indian Face Database

2. Creation of Neural Network

To create a backpropagation neural network newff function is used. It requires four inputs and returns the network object. The first input is an R by 2 matrix of minimum and maximum values for each of the R elements of the input vector. The second input is an array containing the sizes of each layer. The third input is a cell array containing the names of the transfer functions to be used in each layer. The final input contains the name of the training function to be used.

net = newff(PR,[S1 S2...SNl],{TF1 TF2...TFNl},BTF,BLF,PF)

PR — R x 2 matrix of min and max values for R input elements

Si — Size of ith layer, for Nl layers

TFi — Transfer function of ith layer, default = 'tansig'

BTF — Backpropagation network training function, default = 'traingdx'

BLF — Backpropagation weight/bias learning function, default = 'learngdm'
PF — Performance function, default = 'mse'

In backpropagation neural network 'logsig'- log-Sigmoid transfer function is used.

To create a radial basis neural network newrb function is used :

net = newrb (P,T,GOAL,SPREAD)

where P,T are the input and target vectors respectively. The next two parameters goal and spread is explained in the next section.

To create a probabilistic neural network newpnn function is used:

net= newpnn(P,T)

where P and T are the input and target vectors.

3. Training of Neural Network

The physical characteristics will act as inputs to a neural network and the face recognition will be target. Given an input, which constitutes the five observed values for the physical characteristics of a face, the neural network is expected to identify if the face is same or different. This is achieved by presenting previously recorded inputs to a neural network and then tuning it to produce the desired target outputs.

4. Testing of Neural Network

To test the performance of neural networks, values of face attributes, which is given to the neural network for training has been changed and then presented to the different neural networks.

8. Results

Figure 4. Input Images

Firstly, all the three neural networks were tested on 10 face images, then on 20 images, up to 50 face images. Recognition Results of Neural Networks are shown in the table:

Table1: Best Classification Rates of different Neural Networks

No. of Faces presented to the Neural Networks	Recognition Rate of Back Propagation Neural Network	Recognition Rate of Radial Basis Neural Network	Recognition Rate of Probabilistic Neural Network
10	100%	100%	100%
20	100%	100%	100%
30	100%	93.33%	100%
40	90%	87.5%	100%
50	84%	60%	90%

Fig. shows the graph obtained with Back Propagation Neural Network, Radial Basis Neural Network and Probabilistic Neural Network varying number of faces.

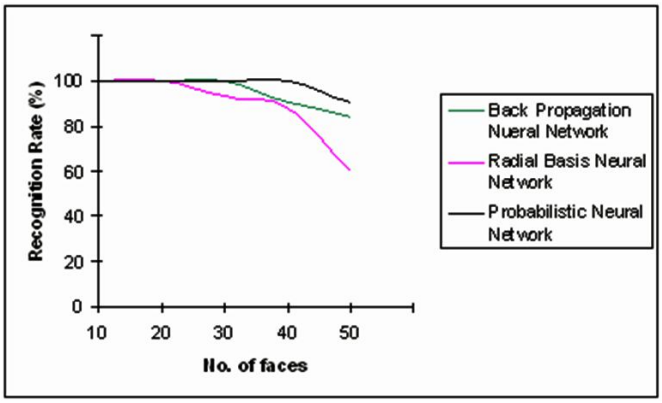

Figure 5: Performance Graph

From the above results it is proved that the **Probabilistic Neural Network** performs best.

9. Conclusion and future work

In this thesis work, I have implemented three neural networks: Back propagation neural network, Radial basis neural network and Probabilistic neural network using MATLAB and their recognition rates have been compared.The main limitation of the implemented system is that it only recognizes upright frontal faces and the variations like rotated faces and side views are restricted and it is time consuming also.

The goal of future work is to improve the recognition rate for varied input data.

10. References

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