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# Review: Face Detection and Recognition Techniques

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***Abstract*- Human face plays an important role in our social interaction, conveying people's identity but it is a dynamic object and has a high degree of variability in its appearences.So to overcome this variability Face Detection and face recognition methods have been introduced. Face detection is the basic step of face recognition. In this paper, we present a comprehensive and critical survey of face detection and face recognition techniques. We present a neural network solution which comprises of identifying a face image from the face's unique features. The basic idea is to identify some unique features in the face image of a person, extract that feature and compare. Approach and various methods which involve the text detection in natural image and extract the aligned text with composite background. In face recognition, we propose the concept of neural networks and PCA,LDA,MPCALDA in which we recognize an unknown test image by comparing it with the known training images stored in the database as well as give information regarding the person recognized. Back propagation algorithm give different rates of accuracy under different conditions as experimentally observed. In face detection, we have developed an algorithm that can detect human faces from an image. This paper describes our research progress towards a different approach for recognition techniques.**

***Keywords* – .Face detection, Face recognition, Neural Networks, SVM, RBF, PCA, LDA, MPCALDA, Back Propagation.**

## I. INTRODUCTION

Face detection involves separating image windows into two classes; one containing faces (targets), and one containing the background (clutter). It is difficult because although commonalities exist between faces, they can vary considerably in terms of age, skin colour and facial expression. The problem is further complicated by differing lighting conditions, image qualities and geometries, as well as the possibility of partial occlusion and
disguise. An ideal face detector would therefore be able to detect the presence of any face under any set of lighting conditions, upon any background.
The face detection task can be broken down into two steps. The first step is a **classification** task that takes some arbitrary image as input and outputs a binary value of yes or no, indicating whether there are any faces present in the image.
The second step is **the face localization** task that aims to take an image as input and output the location of any face or faces within that image as some bounding box with (x, y, width, height).

### A. FACE DETECTION

**The face detection system can be divided into the following steps:-**

**1. Pre-Processing***:* To reduce the variability in the faces, the images are processed before they are fed into the network. All positive examples that is the face images are obtained
by cropping images with frontal faces to include only the front view. All the cropped images are then corrected for lighting through standard algorithms.[4]

**2. Classification:** Neural networks are implemented to classify the images as faces or nonfaces by training on these examples. We use both our implementation of the neural network and the Matlab neural network toolbox for this task. Different network configurations are experimented with to optimize the results.

**3. Localization***:* The trained neural network is then used to search for faces in an image and if present localize them in a bounding box.

**Various Feature of Face on which the work has done on:-**

Position
Scale
Orientation
Illumination

### FACE DETECTION TECHNOLOGIES

**The existing techniques to detect faces in an image can be classified broadly into five categories** :-

1. Knowledge-based methods
2. Feature invariant methods
3. Template matching methods
4. Appearance based methods
5. Agent Based Methods

**Knowledge based methods** are rule based methods that describe a face based on rules. The approach suffers from the difficulty of coming up with well defined rules.

**The feature invariant methods** extract features like eyes, nose, mouth etc and then use them to detect a face. The problem with these algorithms is that these features are

corrupted due to illumination, occlusion and noise. Proposed agent-based methods use collaborative evolutionary agents to search skin-like pixels and segment the face region. The shape of the region is then parameterized by height, aspect ratio and orientation, and classified as a face based on color and shape.[8]

**The template matching methods,** standard patterns of a face or features are stored and the input images are correlated with these patterns to detect a face. These methods fail to deal with variations in pose, scale and shape.[9]

**The appearance based methods,** on the other hand, use statistical and machine learning techniques to learn characteristics of face and non-face images from examples. The learned characteristics are in the form of distribution models or discriminant functions that are subsequently used for face detection. Also, dimensionality reduction is one of the important steps carried out in these methods to reduce computational complexity and improve detection efficacy. As the neural network approach is one of the appearance based methods.

**Appearance based approaches are:-**

**Eigen faces:** The idea is that given a collection of n x m pixel training images represented as vectors, basis vectors spanning the optimal subspace are determined such that the mean square error between the projection of the training images into this subspace and the original images is minimized. Principal component analysis as an extension to this approach has been applied to face recognition and detection [4].

**Support vector Machine:** Support Vector Machines (SVMs) can be considered as a new paradigm to train polynomial function, neural networks, or radial basis function classifiers. SVM classifier is a linear classifier where the separating hyperplane is chosen to minimize the expected classification error of the unseen and the seen test patterns.This optimal hyperplane is defined as a weighted combination of a small subset of the training vectors called the support vectors. Osuna et al [5] developed an efficient method to train an SVM for large scale problems and applied to face detection.

**Radial Basis Functions:-** The main idea of an RBF neural network is to partition theinput space into a number of subspaces which are in the form of hyperspheres. Accordingly, clustering algorithms (k-means clustering, fuzzy k-means clustering and hierarchicalclustering) are widely used in RBF neural networks.

**A. REF architecture:**

Radial basis function (RBF) networks typically have 3 layers: an input layer, a hidden layer with a non-linear RBF activation function and a linear output layer. At the output layer, linear combinations of the hidden layer node responses are added to form the output. The name RBF comes from the fact that the basis functions in the hidden layer nodes are radically symmetric. The most common choice of the basis function is the Gaussian function which can be defined by a mean and a standard deviation. In RBF networks, the connections between the input and the hidden layers are not weighted. The output of the network is thus

$$Yk = L\ Wkj\ exp(\ -llx\ -cJ\ II\ /2(YJ\ )\ ]=1$$

where N is the number of neurons in the hidden layer, Cj is the center vector for neuron}, crj is the spread of the basis functions at the hidden layer nodes, and Wkj are the weights of the linear output neuron. The Ilx -cj II is the distance between the point representing the input X and the centre of the }th hidden node as measured by some norm. In this study, the Euclidean norm is used.

**Hidden Markov Models (HMM):** The goal of training an HMM for a pattern recognition problem is to maximize the probability of observing the training data by adjusting the parameters in the HMM model with the standard Viterbi segmentation method and Baum-Welch algorithms. After an HMM has been trained, the output probability of an observation determines the class to which it belongs. In face detection task, a face pattern can be divided into several regions such as eyes, nose, mouth etc. A face pattern can then be recognition by observing these regions in the appropriate order. In contrast to the template matching approach, here the idea is to associate the facial regions with the states of a continuous density Hidden Markov Model.

**Neural networks**: Neural networks have been extensively applied to numerous pattern recognition problems such as character recognition, object recognition and autonomous robot driving. Various networks have been proposed over the years for the face detection task which is a two class pattern recognition problem. The advantage of using the neural networks is its ability to capture the complexity of the face patterns. However, the disadvantage is that the network architecture has to be extensively tuned (number of layers, number of nodes, learning rates etc) to obtain good results.[10]

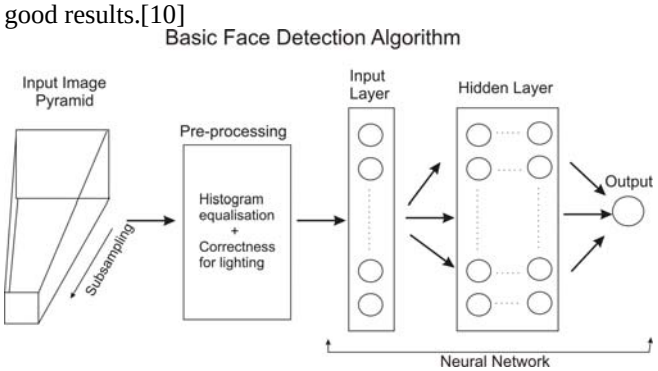



**Fig.1 Face detection Algorithm**

**B. FACE RECOGNITION SYSTEM**

Face recognition is an interesting and successful application of Pattern recognition and Image analysis. Facial images are essential for intelligent vision-based human computer interaction. Face processing is based on the fact that the information about a user's identity can be extracted from the images and the computers can act accordingly. Face detection has many applications, ranging

from entertainment, Information security, and Biometrics [1]. Numerous techniques have been proposed to detect faces in a single image.

Face Recognition System is a computer based digital technology and is an active area of research. The Face Recognition System has various applications like various authentication systems, security systems and searching of persons etc.[6]

As the brain of human beings create the learning ability to recognize the persons by face even the feature characteristics of the face changes with time. The neurons of the human brain are trained by reading or learning the face of a person and they can identify that face quickly even after several years. This ability of training and identifying is converted into machine systems using the Artificial Neural Networks. The basic function for the face recognition system is to compare the face of a person which is to be recognized with the faces already trained in the Artificial Neural Networks and it recognized the best matching face as output even at different lightening conditions, viewing conditions and facial expressions.

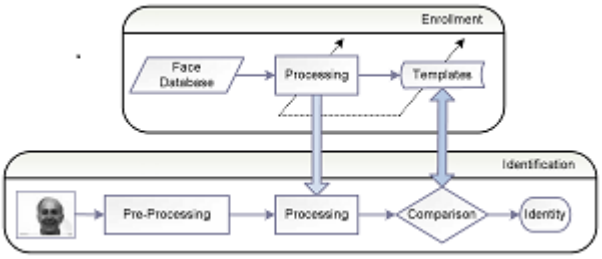



**Fig.2 Basic Face Recognition System**

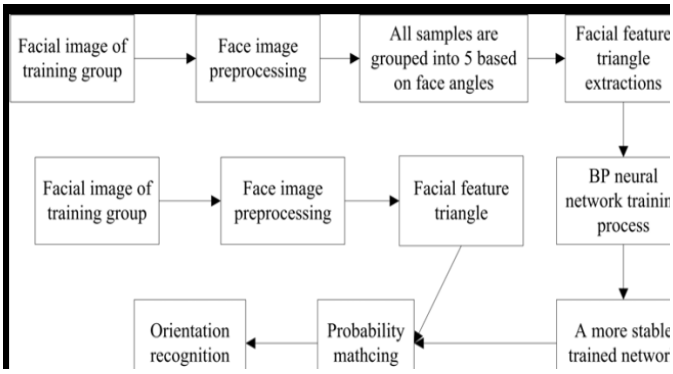



**Fig.3 Face Detection And Recognition Diagram**

**Face Recognition can be done in two ways:**

a)Still image
b)video

The face recognition algorithms used here are Principal Component Analysis(PCA), Multilinear Principal Component Analysis (MPCA)[3] and Linear Discriminant Analysis(LDA).

Every algorithm has its own advantage. While PCA is the most simple and fast algorithm, MPCA and LDA which have been applied together as a single algorithm named MPCALDA provide better results under complex circumstances like face position, luminance variation etc.

## II. LITERATUE REVIEW

**Principles on which Face Recognition is based**

**1. PRINCIPAL COMPONENT ANALYSIS (PCA)**

**Principal component analysis (PCA)** was invented in 1901 by Karl Pearson. PCA involves a mathematical procedure that transforms a number of possibly correlated variables into a number of uncorrelated variables called principal components, related to the original variables by an orthogonal transformation. PCA projects the data along the directions where variations in the data are maximum[11].

PCA method computes the maximum variations in data with converting it from high dimensional image space to low dimensional image space. These extracted projections of face images are further processed to Artificial Neural Networks for training and testing purposes

The major advantage of **PCA** is that the eigenface approach helps reducing the size of the database required for recognition of a test image. The trained images are not stored as raw images rather they are stored as their weights which are found out projecting each and every trained image to the set of eigenfaces obtained.

**2. MPCALDA**

**a) MPCA**

Multilinear Principal Component Analysis(MPCA)[3] is the extension of PCA that uses multilinear algebra and proficient of learning the interactions of the multiple factors like different viewpoints, different lighting conditions, different expressions etc.

The approach is similar to PCA in which the features representing a face are reduced by eigenface approach. While in PCA only one transformation vector was used, in MPCA N number of different transformation vectors representing the different dimensionality of the face images are applied.

**b) LDA**

LDA which is known as Linear Discriminant Analysis[2] is a computational scheme for evaluating the significance of different facial attributes in terms of their discrimination power.

The database is divided into a number of classes each class contains a set of images of the same person in different viewing conditions like different frontal views, facial expression, different lighting and background conditions and images with or without glasses etc. It is also assumed that all images consist of only the face regions and are of same size.

By defining all the face images of the same person in one class and faces of other people in different classes we can establish a model for performing cluster separation analysis.

**3) Neural Network approach**

An Artificial Neural Network (ANN) is an information processing paradigm that is inspired by the way biological nervous systems, such as the brain, process information. The key element of this paradigm is the novel structure of the information processing system. It is composed of a large number of highly interconnected processing elements

(neurones) working in unison to solve specific problems. ANNs, like people, learn by example. An ANN is configured for a specific application, such as pattern recognition or data classification, through a learning process. Learning in biological systems involves adjustments to the synaptic connections that exist between the neurones.

**4)Features of Neural Networks**

**a) Feed-Forward NeuralNetworks**

Feed-forward ANNs 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 ANNs tend to be straight forward networks that associate inputs with outputs. They are extensively used in pattern recognition. This type of organisation is also referred to as bottom-up or top-down.

**b) Feedback networks**

Feedback networks (figure 1) can have signals travelling in both directions by introducing loops in the network. Feedback networks are very powerful and can get extremely complicated. Feedback networks are dynamic; their 'state' is changing continuously until they reach an equilibrium point. They remain at the equilibrium point until the input changes and a new equilibrium needs to be found. Feedback architectures are also referred to as interactive or recurrent, although the latter term is often used to denote feedback connections in single-layer organisations.

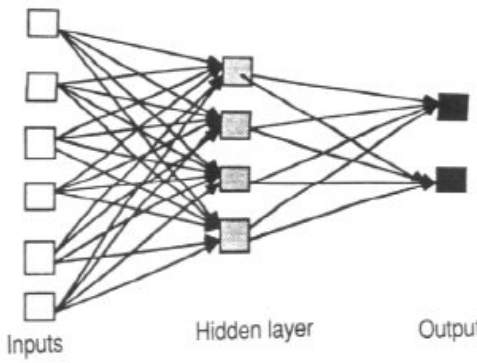



**Figure 4. An Example of a Simple FeedForward Network**

**5.Architecture of Neural Networks**

**a)Network layers**

The commonest type of artificial neural network consists of three groups, or layers, of units: a layer of "**input**" units is connected to a layer of "**hidden**" units, which is connected to a layer of "**output**" units. (Figure 4)

- The activity of the input units represents the raw information that is fed into the network.
- The activity of each hidden unit is determined by the activities of the input units and the weights on the connections between the input and the hidden units.
- The behaviour of the output units depends on the activity of the hidden units and the weights between the hidden and output units.

This simple type of network is interesting because the hidden units are free to construct their own representations of the input. The weights between the input and hidden units determine when each hidden unit is active, and so by modifying these weights, a hidden unit can choose what it represents.

We also distinguish single-layer and multi-layer architectures. The single-layer organisation, in which all units are connected to one another, constitutes the most general case and is of more potential computational power than hierarchically structured multi-layer organisations. In multi-layer networks, units are often numbered by layer, instead of following a global numbering.

**b)Perceptrons**

The most influential work on neural nets in the 60's went under the heading of 'perceptrons' a term coined by Frank Rosenblatt. The perceptron turns out to be an MCP model ( neuron with weighted inputs ) with some additional, fixed, pre--processing. Units labelled A1, A2, Aj , Ap are called association units and their task is to extract specific, localised featured from the input images. Perceptrons mimic the basic idea behind the mammalian visual system. They were mainly used in pattern recognition even though their capabilities extended a lot more.

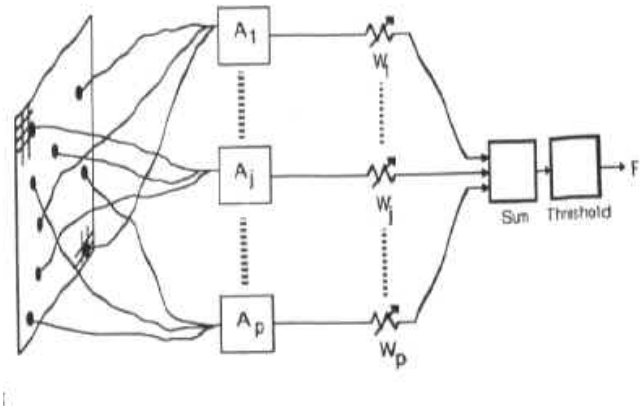



**Fig.5 Working of Perceptron**

**c) MultiLayer Perceptron**

**Feedforward Neural Network**

The back-propagation is the well known and widely used learning algorithm in training multilayer perceptrons (MLP). In MLP feedforward network, the neurons are organized in the form of layers. The MLP network consists of a set of sensory units (source nodes) that constitute the input layer, one or more hidden layers of computation nodes, and an output layer of computation nodes. The input signal propagates through the network in a forward direction, from left to right and on a layer-by-Iayer basis. Back propagation is a supervised learning network based on gradient descent learning rule. The BPNN provides a computationally efficient method for changing theweights in feedforward network, with differentiable activation function units, to learn a training set of input-output data.[12]

Being a gradient descent method, it minimizes the total squared error of the output computed by the net. The aim is to train the network to achieve a balance between the ability to respond correctly to the input patterns that are used for training and the ability to provide good responses to the inputs that are similar.

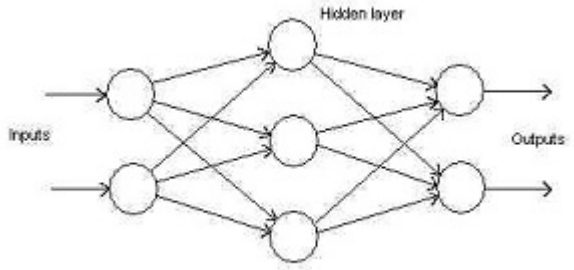
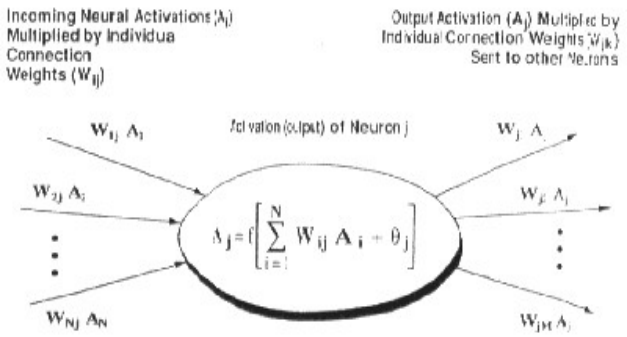



**Fig.6 Layers of Neural Network**

**d)The Learning Process**

Every neural network posseses knowledge which is contained in the values of the connections weights. Modifying the knowledge stored in the network as a function of experience implies a learning rule for changing the values of the weights.




Information is stored in the weight matrix W of a neural network. Learning is the determination of the weights.

All learning methods used for adaptive neural networks can be classified into two major categories:

**5.3.1Supervised learning** which incorporates an external teacher, so that each output unit is told what its desired response to input signals ought to be. During the learning process global information may be required. Paradigms of supervised learning include error-correction learning, reinforcement learning and stochastic learning. An important issue concerning supervised learning is the problem of error convergence, ie the minimization of error between the desired and computed unit values. The aim is to determine a set of weights which minimizes the error. One well-known method, which is common to many learning paradigms is the least mean square (LMS) convergence.

**5.3.2 Unsupervised learning** uses no external teacher and is based upon only local information. It is also referred to as self-organization, in the sense that it self-organizes data presented to the network and detects their emergent collective properties. Paradigms of unsupervised learning [13]are Hebbian learning and competitive learning. Ano2.2 From Human Neurons to Artificial Neuron either aspect of learning concerns the distinction or not of a separate phase, during which the network is trained, and a subsequent operation phase. We say that a neural network learns off-line if the learning phase and the operation phase are distinct. A neural network learns on-line if it learns and operates at the same time. Usually, supervised learning is performed off-line, whereas unsupervised learning is performed on-line.

**e) Transfer Function**

The behavior of an ANN (Artificial Neural Network) depends on both the weights and the input-output function (transfer function) that is specified for the units. This function typically falls into one of three categories:

linear (or ramp)
threshold
sigmoid

For **linear units**, the output activity is proportional to the total weighted output.

For **threshold units**, the output is set at one of two levels, depending on whether the total input is greater than or less than some threshold value.

For **sigmoid units**, the output varies continuously but not linearly as the input changes. Sigmoid units bear a greater resemblance to real neurones than do linear or threshold units, but all three must be considered rough approximations.

**f) Back Propaation**

The back propagation (BP) neural network algorithm is a multi-layer feedforward network trained according to error back propagation algorithm and is one of the most widely applied neural network models. BP network can be used to learn and store a great deal of mapping relations of input-output model, and no need to disclose in advance the mathematical equation that describes these mapping relations. Its learning rule is to adopt the steepest descent method in which the back propagation is used to regulate the weight value and threshold value of the network to achieve the minimum error sum of square. This paper focuses on the analysis of the characteristics and mathematical theory of BP neural network and also points out the shortcomings of BP algorithm as well as several methods for improvement.

An artificial neural network (ANN) is an information processing paradigm that is inspired by the way biological nervous systems process information. It is configured for a specific application through a specific learning process. The most commonly used family of neural networks for pattern classification tasks is the feed-forward network, which includes multilayer perceptron and

Radial-Basis Function (RBF) networks.: Back propagation is a feed forward supervised learning network. The general idea with thebackpropagation algorithm is to use gradient descent to update the weights to minimize thesquared error between the network output values and the target output values. The update rulesare derived by taking the partial derivative of the error function with respect to the weights todetermine each weight's contribution to the error. Then, each weight is adjusted. This processoccurs iteratively for each layer of the network, starting with the last set of weights, and workingback towards the input layer, hence the name "backpropagation". The network is trained

toperform its ability to respond correctly to the input patterns that are used for training and toprovide good response to input that are similar**.**

**6.Neural Networks in face Recognition**

**a)Related Work**

Feature extraction of the human faces by PCA based eigenface approach reduces the high dimensional space into very low dimensions. There are various successful methodologies are purposed in past decades. In 1990, Kirby and Sirovich [5] have shown that the face images can be represented in terms of a best coordinate system termed as "eigenfaces".

These are the eigenfunctions of the average covariance of the ensemble of faces. They also purposed that even for large number of faces, the small number of eigenfaces needed. In 1991, M.A. Turk and A.P. Pentland [14] proposed a face recognition method based on the eigenfaces representation of faces. Various feature extraction methods for face images purposed in last years as Linear Discriminant Analysis (LDA), Kernel methods, Evolutionary Pursuit (EP) Support Vector Machine (SVM) and Artificial Neural Networks(ANN). LDA is a supervised learning algorithm. LDP features are obtained by computing the edge response values in all eight directions at each pixel position.

All projected samples will form the maximum between-class scatter and the minimum within-class scatter simultaneously in the projective feature space. Each face is represented as a collection of LDP codes for face recognition process [11].

Evolutionary Pursuit (EP) is a genetic algorithm which resolves the problem of the dimension of the solution space. It is an eigenspace-based adaptive approach that searches for the best set of projection axes in order to maximize a fitness function, measuring at the same time the classification accuracy and generalization ability of the system [9].Kernel methods provide a generalization of linear methods. Direct non-linear manifold schemes are explored to learn this non-linear manifold .

Support Vector Machine (SVM) finds the hyperplane that separates the largest possible fraction of points of the same class on the same side, while maximizing the distance from either class to the hyperplane.

PCA is first used to extract features of face images and then discrimination functions between each pair of images are learned by SVM.Artificial Neural Networks (ANN) is a very robust and powerful classification technique that has been used to approximate real-valued, discrete-valued and vector-valued functions from various examples .

In 1990, Fleming and Cottrell [15] train the system by back propagation using nonlinear units. Learning ability of neurons is used to analyze the different face distances and the parts of backgrounds by training the network.

This purposed work explains a complete face recognition system by combining the Principal Components Analysis (PCA) based feature extraction with Artificial Neural Networks (ANN) based detection system for improving the success rate and defining the rejection rate. The work is shown using 49 colored face images database with MATLAB simulation.

**7. Implementation Result**

For Face Recognition purpose, the learning process of ANN is used with back propagation algorithm. Back Propagation is a feed forward supervised learning network. There are many types of ANN like Multilayered Perceptron, Kohonen networks and Radial Basis Function.

The multilayered feed forward neural networks consist of the three layers as input layer, hidden layer and output layer as shown in Fig. 7. These layers of processing elements make independent computation of data and pass it to another layer.

The computation of processing elements is completed on the basis of weighted sum of the inputs. The output is compared with the target value and the mean square error is calculated which is processed back to the hidden layer to adjust its weights.

This process occurs iteration for each layer to minimize the error by repeatedly adjusting the weight of each layer.

Hence, it is called the back propagation. The iteration process carried on until the error falls below the tolerance level.

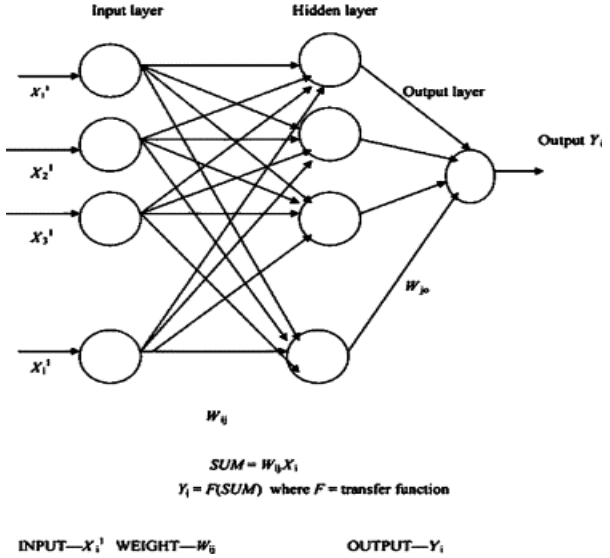



**Fig.7 Basic diagram of neural network**

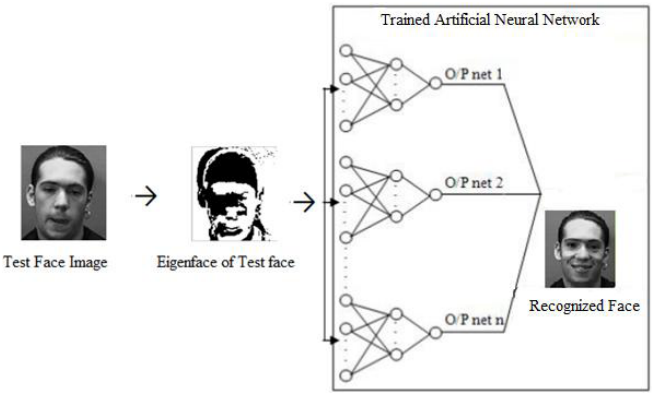



**Fig.8 Testing the Artificial Neural Networks with known Face Image with different expressions Similarly, testing of the non-human face images and unknown face images are rejected showing the access denied as shown in Fig. 10**.

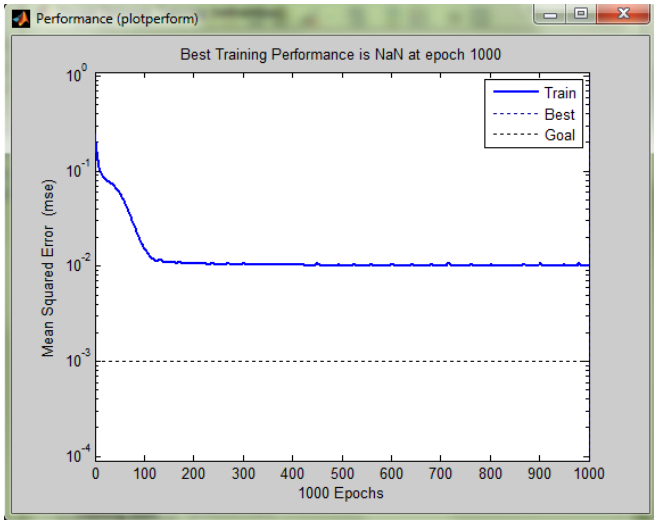



**Fig.9 Performance plot between Mean Square Error and number of Iterations of Artificial Neural Networks**

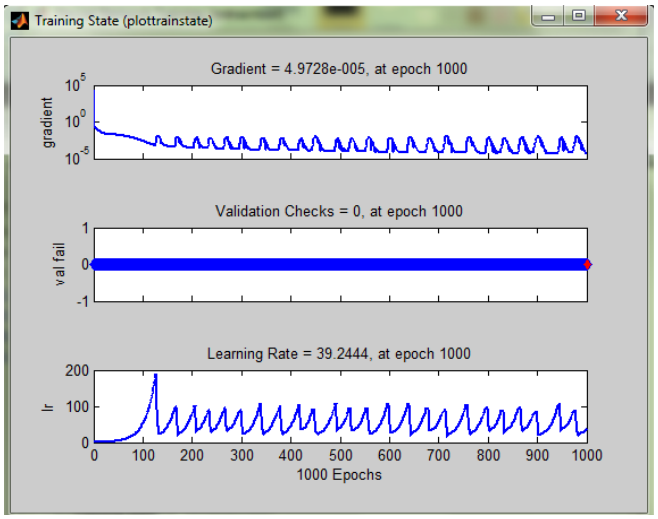



**Fig. 10 shows the performance graph as the MSE (mean square error) is reduced to 0.001 by updating the weights of hidden layer using the back propagation algorithm.**

## III. CONCLUSION

Human face detection is often the first-step in the recognition process as detecting the location of a face in an image, prior to attempting recognition can focus computational resources on the face area of the image.

Here one of the face recognition techniques that are eigenface and one of the face detection technique which is based on neural networks has been shown here.

In Neural networks, MSNN model has developed which is reliable.Back propagation feed-forward Artificial Neural Networks with features extraction using PCA is purposed for face recognition.

The purposed face recognition system works with high accuracy and provides better success rates even for noisy face images. The mean square error converges to 0.001 as set tolerance level and it can be reduced further by increasing the iterations using Log-sigmoid and Tang-sigmoid functions. Results show that when lightening variations are large then it is difficult to count the image distance due to introduced biases in distance calculations.

The purposed algorithm works better than individual PCA based Face Recognition System even in illumination and background variations. This work also improves the rejection rate for non-human and unknown face images. In future, we will apply the local features extraction methods with Artificial Neural Networks for further improvements in the research of Face Recognition System. This method provides the maximum accuracy of about 95.45% for applied database.

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