Low Resolution Multi Neural Network Based Face Recognition

Thesis submitted to the faculty of Engineering and Technology IIU in partial fulfillment of requirements for the Degree of MS Electronics engineering with specialization in Image Processing.

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Certificate of Approval

This is to certify that the work contained in this thesis entitled

"LOW RESOLUTION MULTI NEURAL NETWORK BASED FACE RECOGNITION"

Was carried out by
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Under my supervision and that in my opinion, it is fully adequate, in scope and quality, for the Degree of MS Electronics Engineering from International Islamic University Islamabad

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DEDICATION


To My Family
Members
Because Their
Prayers Are
Always With Me

Declaration

Undersigned certify that the research work carried out on LOW RESOLUTION MULTI NEURAL NETWORK BASED FACE Recognition is of my own. The accuracy rate has been improved and such work based on novel idea of Multi Neural Network has not been submitted before, to qualify for any other academic award. The contents of thesis are drawn from the research work carried out.

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Acknowledgement

In the name of Allah, The Most Gracious, the most Merciful. All praise and glory goes to Almighty Allah, who gave me the courage and patience to carry out this research work. First and foremost, I would like to express my sincere thanks to my wife, children and others family members for their support and patience during my study period, their support always gave me the determination to finish my work in time.

My special thanks go to Aleem Arshad Dy. Director General (AT), NDC for his administrative support during my study period.

I would like to express my gratitude to Dr. Rab Nawaz, my research work adviser for his guidance, encouragement and practical help to execute my research work and Matlab Simulations during my Master program.

I extend my gratitude to Dr. Ihsan, Coordinator MSEE Program, International Islamic University,Islamabad for his guidance to prepare Thesis Synopsis and approval.

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Abstract

Multiple neural networks have been used in bio-metric applications mostly to form an ensemble of classifiers for boosting or for using them as mixture of experts. Training a dedicated network for each subject has been previously suggested in few of the papers on face recognition. The training was not intuitive and/or the complexity increase problem was not handled. In our approach, each neural network is shown not only its own subject images but also those of other subjects. We show better accuracy and at the same keep the computational complexity of training and testing phases low by using a very few number of neurons. Our approach is so rich that we get better accuracy using only 0.6 times the image resolution as compared to other multi net approaches. This makes our application useful in scenarios where high resolution face images are not possible to acquire e.g., in surveillance applications. We cascade first stage of the multi nets with a second phase correlation stage. We reduce the search space for the second stage by giving only top 10 matches from the first stage. We calculate a confidence measure of the 1st stage classifier based on results of the first stage and only opt for the second stage if the confidence measure is below a threshold. Furthermore, the decision of the second stage is kept only if the confidence of the second stage is higher than that of the first stage; otherwise decision of the first stage is kept intact. This conditional cascading not only improves accuracy of the overall face recognition system but also reduces the complexity.

CHAPTER 1

INTRODUCTION

1.1Biometrics explanation

Biometrics means "recognition of a person using its traits." A better definition of biometrics is "recognize a person using person traits". The biometric is very robust technique, it can recognize a person even there are physical changes. These changes may has happened due to injury, illness, age or exposure to some chemicals.

The iris does not change during lifetime; it is a better technique than voice [9] – [26]. The iris and retina are better to be used than finger and hand. Biometric- systems can be used for financial transactions and data protection. Biometric scan also be used in federal governments, in the military, and in commercial applications. Biometrics systems can be used in networks, data protection, transaction security and Web security. Biometrics are frequently used in our daily life. Biometric is more authentic as compare to others methods Such as PINS or passwords. Biometrics involves a particular individual only.

1.2 Authenticity

Peoples are always using Cards, PIN, Token and keys for keeping the system secure and safe. All these things to be remembered. If you are using Biometrics, then it means person itself is available for authenticity [11].

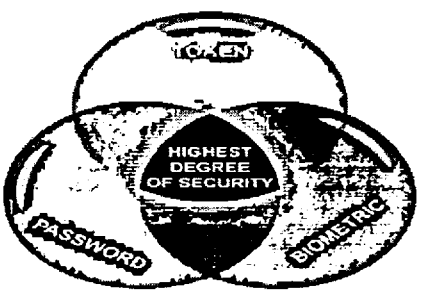

Figure 1- Level of Authentication

1.3 Biometric System Components

Sensors collect data and convert the information to a digital format. Signal processing algorithms perform quality control activities and develop the biometric template. Data Storage keeps information so that new biometric templates will be compared. Matching algorithms compares the new biometric template to one or more templates available in data storage.Decision process uses the results from the matching component to make a system level decision. Some of the major examples include [11].

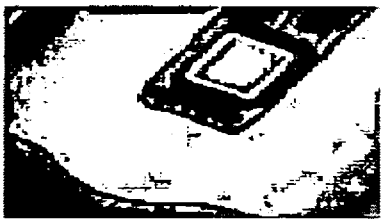

Figure 2 - Biometric System Components

1.4 Biometric Examples

Commonly implemented biometric examples include fingerprint, face, iris, voice, signature and hand geometry. Many other examples are in various stages of development e.g. Gait, vascular, retina and Facial Thermography. There is not one biometric example that is best for all implementation. So many factors are taken into account when implementing a biometric device including location, security risks, task (identification).Number of users required, user circumstances, data available etc. It is also important to note that biometric examples have achieved some mature level. Some of the examples are given below [11].

Figure 3-Biometric Examples

1.5 Hand Geometry

Hand print signature is unique and no one can forget it. This technique is being used from 31,000 years back. It is supposed that hand prints were used to recognize a person from 500B.C.Chines merchants were using finger prints for different tasks e.g Transactions, Trading, to differentiate children.

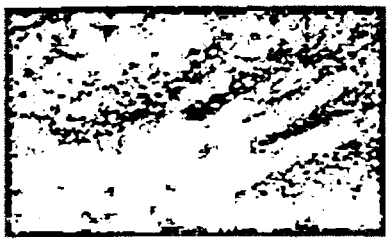

Figure 4-Hand Geometry

1.6 Face Recognition

Face recognition is one method among so many biometrics examples. It has high accuracy. This method is being used from 1970 by Kelly [26]-[24]. Individual can recognize through faces. Now due to advancement in computing, faces can be recognized automatically. In old days only geometric methods were used for face recognition. But now face recognition is carried out mathematically and matching processes. So many approaches are used for 2D face recognition. Recently face recognition is carried out through Neural Network. My research work is also based upon Neural Network approach.

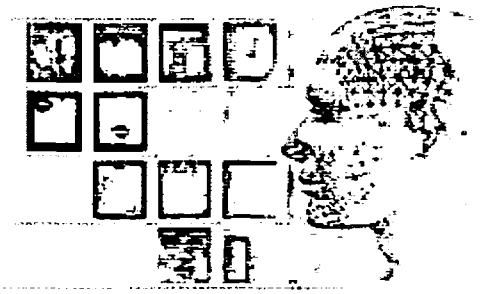

Figure 5-Face Recognition

1.7 Recognition through Finger Print

Studies on finger print started during 1800s and early 1900s.It is a well known Biometrics method. Finger prints are unique. So finger prints are used from centuries for recognition. Now it is automatic due to advancement in computing. It is a popular method for recognition because it is easy to be used. Finger prints possess uneven surfaces of ridges and valleys. It results in to a unique pattern to each individual [11].

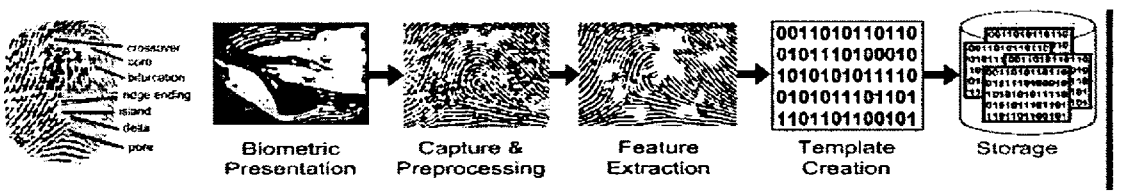

Figure 6 - Finger Print Recognition

1.8 Palm Print Recognition

It is similar like fmger print characteristics. Palm biometrics is represented through ridge impression. Likefinger, palm prints are unique and permanenet.However, it is slower as compare to fmger print due to some constraints in computing processes [11].

1.9 Iris Recognition

A person can be recognized through iris by analyzing the random pattern of iris. Iris is actually a muscle in the eye. It regulate pupil. It controls the amount of light that enter in to eye. It is a colored portion in the eye. The color is due to amount of melatonin pigment with in muscle. The color and structure is due to is linked genetically. It is developed from childhood .As it is genetically linked, so individual iris is unique and structure varies. So it

can be used for recognition purpose. To take the image of iris, recognition system illuminates the iris by using infra red light [11].

1.10 Hand Geometry

The first product introduced in the market was based upon hand geometry. The system is used frequently for recognition. It is not a high recognition method, so application is limited. First PIN code is used and then put the hand on system. Picture of hand is taken. Mirror is used o see the hand view. Measurements are taken and compared with b already stored information's [11].

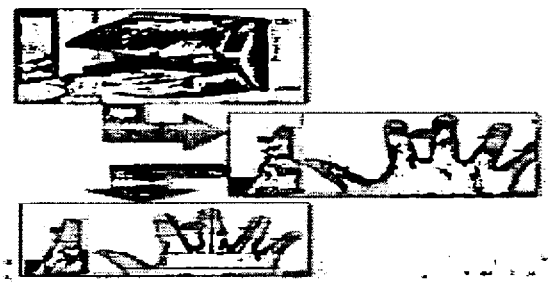

Figure 7- Hand Geometry

1.11 Speaker Recognition

Speech of each individual is considered. Speech is a special feature related to individual Vocal Card. It can be used for recognition purpose [11].

1.12 Dynamic Signatures

It uses the speed and pressure when someone is writing.

Figure 8- Dynamic Signature

1.13 Key strokes Dynamics measures the typing pattern of an individual

1.14 Gait/Body Recognition how someone appears as he walks. Like face recognition, this technique is also used to recognize someone [11].

Figure 9-Gait / Body Recognition

1.15 Facial Thermographs

It measures how much heat is dissipated from individual face.

1.1.1 Face Recognition

The Public identifies a person by looking at his face. So face is very important part of our body. If all the peoples have the same faces, and then it is very difficult to recognize an individual. Even in twins, there is difference in faces. Humans are recognizing a person from the very beginning, but computers are now in use. If a person look at his face in the mirror. Individual will feel different landmarks i.e Peaks and valleys. Thus each face is different.

These landmarks are called nodal points, inhuman face there are so many nodal points, some of them are given below.

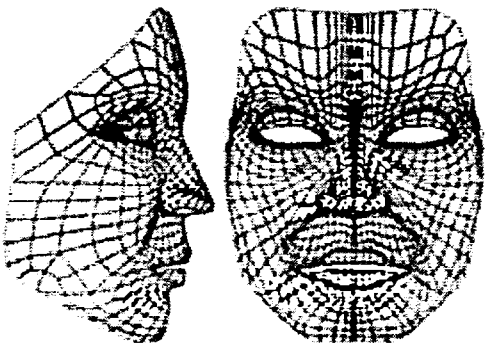

Figure 10- The face

1.1.2 Nodal Points in the face

- Distance between eyes
- Width of nose
- Depth of eye sockets
- Cheekbones
- Jaw line
- Chin

Face recognition is a popular area for researchers. Neuroscientists and psychologists are using this technique [25]. As the computer vision technologies will become more advance Neuroscientists and psychologists will be frequently using this technique. In my research work face recognition is carried out by using Artificial Neural Network.

1.1.3 Mathematics of Face recognition

In face recognition technique, actually matching of faces is carried out with an already stored database of faces. This technique is being used from 1960s.In early ages peoples were

working to understand the features of faces to be used for recognition identifying a person, decide an individual age and gender, facial expression and beauty.

Figure 11-Mathematics of Face recognition

Computer based recognition is a challenge. For this system, there is no effect of external changes i.e light, person position and distance from camera, internal deformations i.e facial expressions ,age and makeup. Peoples commercially use large Data Bases. So recognition should be efficient, tough mathematical modeling is required .Recognition algorithm use two techniques, feature based and image based [25].In feature based, geometric features are used e.g distance between eyes, size of eyes. These features can be calculated using simple correlation filters with templates as an advantage; illumination has no effect on the system. Age and facial expression has effect on the system. Computerized based face recognition document was first prepared by Bledsoe, 40 years ago. This document was using these ideas.

1.1.4 Introduction to Network

Neural Network algorithm is used so that human can use the machines efficiently. Human learn from experience e.g when a teacher say to student learn letter A, student then can recognize the letter A. Human can distinguish a cat from the Bird. Even without a teacher, pattern recognition can be done [10]. ANNS came in to market some 50 years back, the idea

is taken from brain biological structure. Recently ANNs are used due to better training techniques available. It is easy to run NN Simulations on high speed digital computers. Electrical Engineers are using NN in Signal processing, Control, robotics, pattern recognition and for artificial Intelligence.ANN can be considered as information processing system. It is close to Biological Neural Network (BNNs). Neuron is the simple most elements in which information processing occur. Signals are passed from one neuron to other neuron over connection links. There are weight and biases on connection links. These weight and biases are multiplied with information's and then transmitted. Activation function is nonlinear and part of neuron. Internal state of Neuron is called activation or activity level. It is a function of input it has received. Activation is actually a signal and sent to several other neurons. Only one signal is transmitted at a time, but it can be broadcasted to several others neurons. I943 is the origin of first neuron and developed by neurophysiologist Warren McCulloch.

1.1.5 My Research work

Recognizing the faces is my research work. Artificial neurons are used to complete facial recognition work. To complete this work a Multi Neural Network is used. Preprocessing is carried out on data to have a best fit as input to neural network and light computation. Preprocessing include reducing the image size and submitted as input to Neural Network, thus less memory and less time consumed [24]. Back propagation algorithm technique is used to complete the work and simulations.

1.1.6 Neural Networks Applications

Neural Networks are used excessively everywhere in industry and commercial applications. NNs can be used in the following tasks.

- In industrial control
- Data base checking

- Risk management
- To target the market

ANN are also used for other tasks such as in communication, to diagnose diseases, chines words translation and interpretation, to detect mines, to recognize words written by hand and particularly to recognize faces [11].

1. Real Time Operation: computations through NNs are carried out real time in parallel. Special Electronics hardware are developed and manufactured to use ANNs efficiently.
2. Fault Diagnostics: If the network is partially damaged, then performance is reduced. However, network is still capable to work [11].
3. Self-Organization: An ANN is capable to develop its own organization during learning time. It can also represent information it receives during learning.

CHAPTER 2

FACE RECOGNITION TECHNOLOGIES

2.1 Survey on Face Recognition Methods

Review on Face Recognition Methods: Face Recognition has been an attractive matter for both neuroscientists and computer engineers regarding artificial intelligence (AI). Human brain can easily detect and identify the face, on the other hand face recognition for a computer require two steps, the face area should be detected in one step and recognition comes in second step. Therefore, in order to recognize faces for a computer, the face images must be taken in a desired environment; identical poses in a uniform background makes the problem easy to solve. The face images taken are called mug shots. From these mug shots, canonical face images can be formed manually or automatically by several preprocessing techniques like cropping, rotating, histogram equalization and masking. The research history of working of human face recognition system and machine recognition of faces is given in this chapter.

2.2 Human Face Recognition

To make up artificial face recognition systems, engineers and scientists have to be aware of the architecture of human face recognition system. Understanding the methodology of human face recognition system may be helpful to know the basic system. However, the human face recognition system is developed more than that of the machine recognition system. The human face recognition system utilizes information obtained from some or all of the human senses like visual, auditory, tactile, etc. All these information is used individually or collectively for storing and remembering of faces. In many cases, the environment also plays a key role in human face recognition system. It is difficult for a machine recognition system

to gather so much information and their combinations. However, it is too difficult for a human to memorize many faces because of storage limitations. The key benefit of a machine system is its storage capacity, but human face recognition system has the main quality due to its parallel processing capacity. The concern "which features humans use for face recognition" has gone through by engineers and scientists, all researchers argued that both global and local features are used for face recognition. It is difficult for humans to recognize faces which they regard as unattractive. The low spatial frequency elements are used to explain the sex information of the person but high frequency elements are used to recognize the person. The low frequency elements are used for the global narration of the person whereas the high frequency elements are required for better details required in the recognition process. Both holistic and feature data are essential for the human face recognition system. Studies recommend the possibility of global descriptions utilize as a key role for enhanced feature-based observation. If there exists some special features present such as big ears, a small nose, etc. holistic descriptions may not be used. It is also observed from recent studies show that an inverted face (i.e. all the intensity values are subtracted from 255 to obtain the inverse image in the gray scale) is much difficult to recognize than a normal face. Hair, eyes, mouth, face outline for perceiving and remembering faces is to be more important than nose. For face recognition, it has also been observed that the upper part of the face is more useful than the lower part of the face. Also, visual features (like beauty, attractiveness, etc.) play a key role in face recognition; the attractive faces are easily remembered. Photographic negatives of faces are harder to recognize for humans. There is not much information on why it is harder to recognize negative of faces. However, the study shows on why it is easier for humans to recognize faces illuminated from top to bottom than the faces illuminated from bottom to top. According to the neurologists, in human face

recognition system human brain also study the face expressions with face recognition to identify faces. The patients with problems in identifying familiar faces seem to identify facial expressions due to emotions. Patients who suffer from organic brain syndrome are harder to study expression but easy to perform face recognition.

2. 3 Machine Recognition of Faces

Studies on human face recognition system were expected as a reference for machine recognition of faces, development of research on machine recognition has made independently of studies on human face recognition. Same development in face recognition was achieved in the era of 1970's to 1980's, typical pattern classification techniques, which gathered information of features in faces or face profiles, were used. While the early 1990's, research development in the field of machine recognition of faces has grown enormously. Now, the main point to classify the face is that; which points are used to form the algorithm (for face encoding) must take to attain face recognition. Two techniques are used for machine identification of human faces, first is geometrical local feature based methods, and secondly holistic template matching based systems. The combinations of these two methods is called hybrid methods are also used.

2. 4 Face Detection and Recognition by using PCA

Method the Eigen face technique of Turk and Pentland is one of the most important methods. It takes the face images in 2-D data format, and categorizes the face images by scaling them to the eigen face space which consists of eigenvectors acquired through variance of the face images. The Eigen face method of recognition of faces is known to the first working technology for face recognition. Turk and Pentland worked on the image as a whole. Also, they classify the face images by using Nearest Mean classifier. By doing several experiments

they found that the projection of a face image is differ from non-face image, a method of detecting the face in an image is obtained. After experimentation they come to the conclusion that the system was healthy in observing the changes (between different images), but fails to observe if scale changes. This can be clarified by the correspondence between images obtained under different conditions, i.e. Correspondence between face images on different scales is slightly low [8].

2.5 Face recognition through PCA and Gabor Filters:

PCA and Gabor Filters together used for facial recognition was suggested by Chung et al. Recognition done in two parts, firstly, from predefined fiducially points, Gabor Filters has to take out facial features from the original image. Secondly, PCA is optimally used to categorize the facial features. The combination of these two methods is used to get rid of shortcomings of PCA. They concluded that the eigenspace was unable to reflect the correlation of facial feature well when images used as matrix of PCA as original face images have deformed. But they stated that they approximately get rid of these problems by using Gabor Filters during extracting facial features [15].

2.6 Face Recognition by LDA

LDA was done using scatter matrix analysis and technique was developed by Etemad and Chellappa. In this technique projection of LDA is taken in to consideration instead of Eigenvalues used in PCA [9].

2.7 Transformation Based Systems

2.8 Discrete Cosine Transform (DCT)

This method was developed by Podilchuk and Zang. It involves features vectors of faces, these vectors represent critical portion of face. Features vectors of the whole face are taken. During training a code of feature vectors is developed for each person Recognition take place by using the number of features, size of code and feature dimension. They claim that DCT Technique produce features vectors which have very low dimension and better recognition.

2.9 Face Recognition by SVM

The scientist who developed this method for face recognition was Phillips. This method involve known numbers and known individuals. SVM is used as a classifier, a binary technique. They developed face recognition, by taking in to account difference space. Difference space provides dissimilarities between faces of the same person and faces of faces of different persons [16].

CHAPTER 3

FACE RECOGNITION PRE-PROCESSING

3.1 Fundamental Issues in Face Recognition

The fundamental aim in face recognition is the ability to recognize faces despite of fast variation in the appearance in the faces. The face is a 3D instance but the camera capture only the 2D spatial information of the face. Also the fast variation in the lightening conditions further pose the difficulty level to higher degree for image processing expert for accurate face recognition and detection. The variation in the background data of faces including very different faces is also a challenging job for image processing expert. Therefore, the task of image processing is to diminish all these variations in the illumination and other artifacts. The image detection algorithm must be robust enough to avoid all these variations. The variations in the faces themselves further impose the difficulty for the algorithm, so the algorithm must be universal to handle all these variations. The human faces are always varying and a small nuance could make the difference in the face must be recognized by the image processing techniques.

Moreover, the final output of the face recognition algorithm must be robust and accurate. The expertise of recognition should be to identify the person name against the whole database by matching mechanism. In a similar fashion, the system must be robust enough to handle the problems of sensor noise, lightening and noise in the medium.

3.2 Introduction to Face Recognition

In this highly advanced technological world the importance of biometrics system very important. These systems are automatic as well as semiautomatic based on the cost and performance of the underlying system. These systems must be capable to recognize a person

on the basis of physiological and appearance characteristics. Numerous types of biometric algorithms are being used for real-time recognition, the most popular are based on face recognition and fingerprint matching. Moreover, there are many other biometric techniques that are extensively used such as iris, retinal scan, speech, handwritten signature, facial and hand geometry. While every other biometric needs some voluntary action, face recognition can be used passively. So the advantages of face recognitions are both for ease of use and for surreptitious use such as police investigation. Furthermore, this method is more accurate than Fingerprint recognition system.

Face recognition and identification is one of the most interesting tasks for machine recognition systems. Over the last couple of years, face recognition has become an energetic area of research in the world of computer vision and machine learning. It is of foremost importance because of its possible applications in areas such as security, individual checking systems, and teleconferencing. Although human beings can identify faces in cluttered scenes with relative ease, machine recognition is a much more formidable task. Furthermore the psychological studies of human face recognition propose that almost every type of available information is used. Progress has made to the point that face-recognition systems will soon be established in real world applications. The active progress of face recognition is due to a combination of many factors such as research in the field of algorithms development, availability of a large number of datasets of facial images, and a method for assessing the performance of face recognition algorithms.

Although the task of identifying someone from facial features is natural, facial recognition, as a biometric, makes human detection a more automatic and computerized process. The main differences which distinguish facial recognition from other biometrics systems are that it can also be used for surveillance purposes. For example, public safety authorities want to

locate certain individuals such as most wanted criminals, suspected extremists, and missing children. Facial recognition may have the probable to help the authorities with this assignment.

Furthermore the facial recognition system offers several advantages with respect to many other recognition systems. The face recognition system captures faces of people in public areas, which diminish lawful apprehensions for reasons explained below. Moreover, since faces can be captured from some distance away by the use of accurate and high end cameras facial recognition can be completed without any physical interaction. This feature of the process also gives facial recognition a secret or covert ability. For any biometric system to operate, it must have records in its data sets through which it can search for possible matches. Face recognition systems are able to control existing databases in many ways. For example, facial recognition is often able to control current surveillance systems such as surveillance cameras or closed circuit television [9]-[3].

3.3 Five Steps to Facial Recognition

1. Image capturing

2. Crop the face from image

3. Feature extraction

4. Template matching

5. Identify matching

Facial recognition system is a kind of computer vision that utilizes faces to attempt to identify a person or prove a person's claimed identity [16]. Regardless of exact method used, facial recognition system is accomplished in a five step process, which is explained in the following five steps.

1. The very first step in any automatic system is the acquisition of the image. This can be done by using a special camera or by using electro-optical camera to acquire live picture. After image acquisition the image must be cleaned of any noise or must be aligned accurately for further processing.

2. After the initial step of image acquisition the second step is to crop the location of any face in the input image. This is very crucial step in any automatic face recognition system. We have used image crop function of image processing toolbox to extract the exact face image.

3. After the face location in the input image the next step is to analyze the characteristics of the image. There can be many methods to analyze any image. We have used image features as the key points for image analysis. The facial recognition system analyzes the spatial geometry of distinct features of the face. We have used Principle Components Analysis (PCA), for feature reduction and choosing the optimal feature set. This method is often called as Eigen face method. We have combined PCA with Neural Networks for efficient performance and optimization.

4. The template generated in previous step is compared with the known faces of the database. The comparison process produces scores that how much the generated template matches to the known faces in database. In a verification application, the template under process is only compared with one template in the database in order to claim the identity.

5. The final step is to determine whether the scores produces in the previous step reaches the threshold to claim a perfect match. The guidelines governing the claim of a perfect or close match are often adjusted by the end user based on the security level and operational conditions.

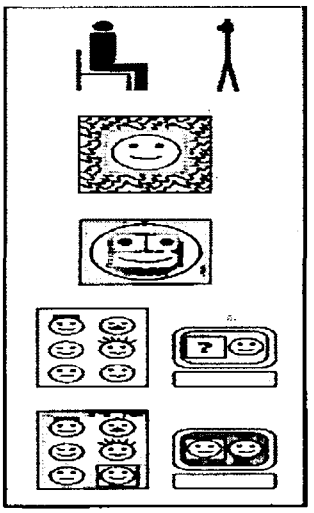

Figure 12-Five Steps to Facial Recognition

Face Recognition Steps

3.4 Histogram

While discussing histogram in image processing context, it is the operation to show the occurrence of each intensity value in image. Basically, the histogram is a graph that shows the intensity of number of pixels at all match value found in the image. There are 256 possible intensities for an 8 bit gray scale image. So the histogram will display 256 numbers showing pixels distribution among gray scale values.

3.5 What is Histogram Equalization

It is the technique that is used to increase the dynamic range of an image's histogram. The advantage of this technique is that the transformed image has uniform distribution of intensity values. From visualization purpose, it increases the contrast of a given image by the redistribution of intensities [18].

The peaks and valleys are shifted after histogram equalization. This process is called spreading, which is better than the counterpart flattening. New values are assigned in histogram equalization.

3.6 General Working

The basic working principle of histogram equalization is described in the following three major steps:

1). Formation of Histogram

2). Assignment of new Intensity Values all Intensity Levels

3). Replacement of the input values with the transformed values

Let us consider a discrete gray scale image of values in the range from 0 to 255, and let n_i be the number of gray levels in the input image and we denote this with letter i. The probability distribution of the image values in the input image can be calculated by using the following expression.

In the above equation L denotes the total number of gray levels and n is the total number of pixels in any given image. So in this equation each gray level is normalized in the range between 0 and 1 and p is the corresponding histogram of the image.

The cumulative distribution function which is a monotonic function with increasing slope can be denoted by the letter C and is defined in the following equation. So the corresponding CDF of histogram can be written as.

$$c(i) = \sum_{j=0}^{i} p(x_j)$$

c is the image's accumulated normalized histogram.

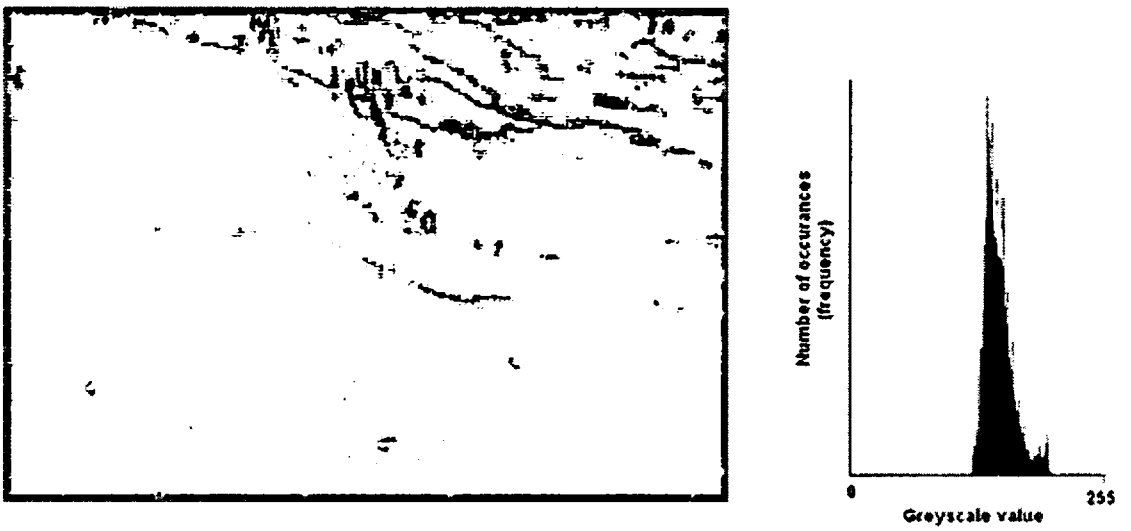

Figure 13 -Histogram Equalization

Figure 14- Histogram Equalization

This method is very useful in those images where foregrounds and backgrounds are bright or dark respectively. This method is of particular importance in photography as well as in the x-ray imaging. In the photography better details can be viewed through histogram equalization. Computationally this method is very efficient and requires very less resources in terms of hardware implementation.This technique of histogram equalization is used in image

comparison and in the correction of non-linear effects introduced by discretization and sampling process.

3.7 Interpolation

Interpolation is the phenomenon in which new data points are estimated based on some known data points. This field is very emerging in the numerical analysis domain and has been widely used these days in image processing applications. In many applications there are situations in which one can get data by experiment or by observations and tries to estimate some future data based on the previous samples, so interpolation is the automatic answer for such situations. Moreover interpolation is a specific case of curve fitting technique. A closely related problem related to curve fitting is the complex function approximation by means of some simple linear as well as nonlinear functions [5].

3.8 Bicubic Interpolation

There are many methods of interpolation used in the domain if image processing for interpolating the intermediate values. There are many methods of interpolation like nearest neighbor interpolation, Bicubic interpolation, and bilinear interpolation.

In Bicubic interpolation method a bicubic surface is fitted through existing data points. The value of an interpolated point is the combination of the sixteen nearby points. This method produces a smooth surface and is called as piecewise bicubic. These characteristics make this method suitable for image processing applications.

The bicubic interpolation is calculated as follows:

The advantage of Bicubic interpolation is that it produces more sophisticated and smoother edges than bilinear interpolation technique. This can be demonstrated with the eyelashes example below.

Bicubic Interpolation method can be explained using the image as under.

The figure below is the image after bicubic Interpolation

Figure 15-Bicubic Interpolated

Figure 16- orignal image

Further more there are two more forms of bicubic Interpolation, comparison of those forms with bicubic interpolation is shown below.

Figure 17-Bicubic

Figure 18-Bicubic Sharper

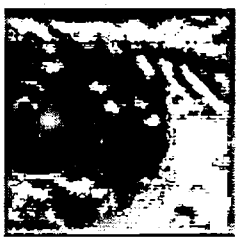

Figure 19-Bicubic Smoother

CHAPTER 4

NEURAL NETWORK

Artificial neural networks can be used by preparing software to simulate Biological neural network.

4.1 Introduction

Artificial neural networks are similar like biological neural systems. The essential part is neuron. Neuron is similar like a biological system. It can have many inputs and can send its output to so many neurons. ANNS can never compete biological neural systems.

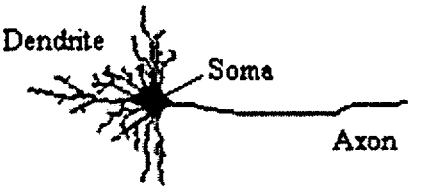

Figure 20-Biological Neuron

The Soma, dendrites and the axons are available in a single cell neuron. Signals from axon go to dendrites and axons transmit the pulses out from soma Neuron takes all the inputs it receives and decide for firing or not. Neuron has a threshold level, below that threshold level it give no output. ANNs has the same configuration as Biological Neural Networks.

4.2 History

- In the 1950's and 1960's Rosenblatt (Perceptron), Widrow and Hoff (ADALINE) started to work on ANNs.
- Back Propagation algorithms were developed in late 1980's
- More Progress was carried out in 1990's duration

Now a days NNs are applicable to work in different fields like insurance, to detect Frauds. To recognize characters, to recognize images and similar so many other applications.

4.3 Artificial Neurons and Human

4.3.1 Human Brain Learning?

In human, there are dendrites for collecting signals. The dendrites send spikes of electrical activity to axon, a thin, long stand. It has thousand of branches. Synapse changes the axon activity in to electrical effect. Neuron receives excitation as an input, it send a spike of electrical activity to axon,axon change it into electrical effects that excite activity in the connected neurons.

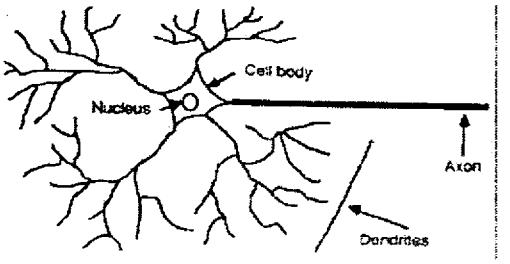

Figure 21- Biological Neuron

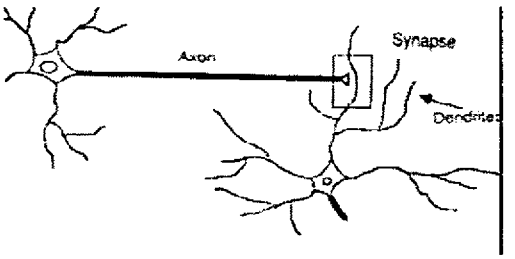

Figure 22- Biological Neuron

Haykin, S. (1994), saidthat a Neural Network is a parallel processor that can store knowledge obtained through experiments and that can be used in future. It is similar to brain in two ways:

a) Neural network gain knowledge through a learning process.

b) Synaptic canstore knowledge and information using weights.

DARPA studied Neural Network IN (1998, AFCEA International Press, page 60), said it consist of simple processing element operating in parallel. Network structure can define the function, strength. Processing is performed at nodes.

(In 1993, Nirgin) said that Neural Networks can be used for Pattern Recognition

4.4 An Engineering Approach

4.4.1 A simple neuron

An artificial neuron possesses many inputs and one output. There are two modes in which neuron can be used, the training mode and the using mode. During training mode, neuron either to fire or not for inputs information. In the next mode i.e using as a taught input is submitted, the associated output then is a current output.

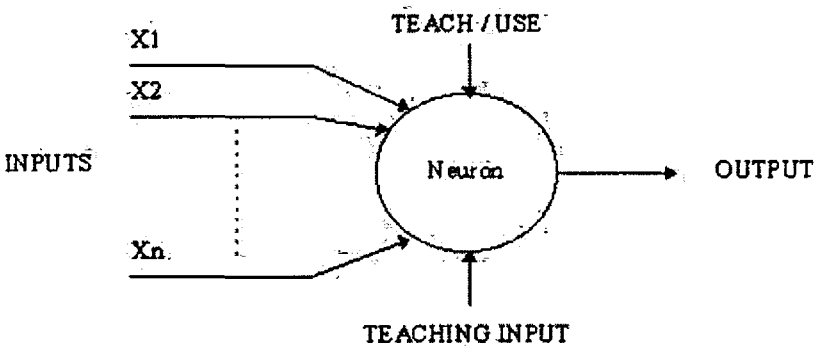

Figure 23-simple neuron

Consider the neuron as a program that has one or more inputs and has one output. The signals are simulated by neuron that is received at input; output simulates the signal which the neuron produces. The output is achieved when all inputs are multiplied by weights, then addition, scaling is carried out between 0 and and 1.

The following fig shows a simple neuron with:

1. The neuron has Three inputs [x1, x2, x3].
2. There are three weights [w1, w2, w3]. , think the weight as a variable of type float/real, you can use it as a random number between 0 and 1.
3. There is one output z. A neuron has one output. The value is between 0 and 1, the value can be scaled.

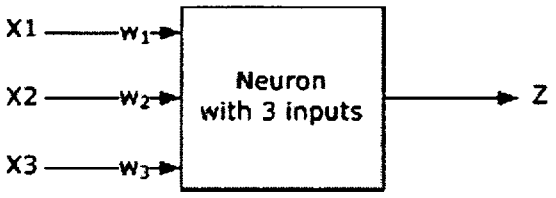

Figure 24-Neuron with 03 inputs

4.4.2 Network layers

There are usually three layers in a neural network, input layer, hidden layer and output layer.

- The activity means the information at the input of network. Hidden unit response depends upon the activities of input unit and the weights on the connections between the input and hidden layer.
- Output units depend on the hidden unit's response and the weights among the hidden and output.

4.4.3 Components of an Artificial Neuron

Input signals (x's) - These signals are received from other neurons available in the system.

Weights (w's) - The weights are multiplied with inputs.

Activation Level (sum of x*w) - The activation level means the sum of the inputs and weights received.

Threshold Function (f) - it produce a positive output for the neuron.

A simple most example of an artificial neuron is shown below:

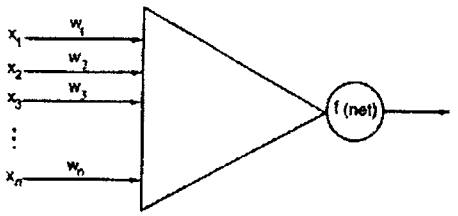

Figure 25-An Artificial Neuron

4.5 Architecture of Neural Networks

4.5.1 Feed-Forward Networks

Neural Network is defined as single layer or multilayer. The multilayer net is shown in Figure below. It is an example of feed forward nets. In this net the signals flow from the input to the outputs units, in a forward direction only.

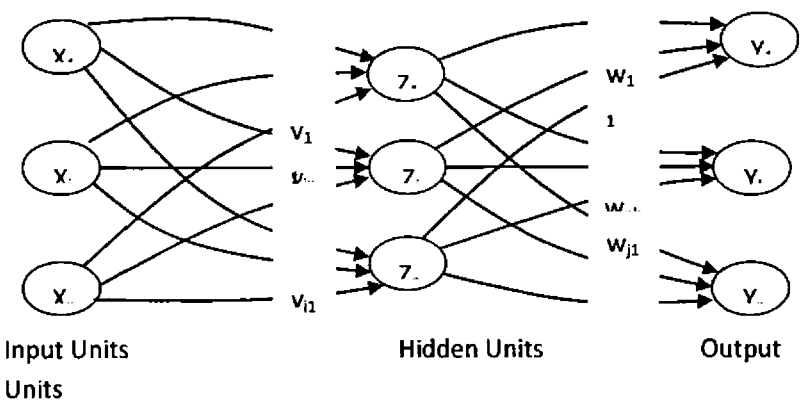

Figure 26-Feed Forward Neural Network

Training rules exist; weights are adjusted depending upon data.

Neural Net is used to learn through examples as children learn, and then can recognize.

4.5.2 Backpropagation Neural Network

Back propagation is also known as Delta rule. It is used to minimize the error of the output in a net. Training algorithm was developed by Rumelhart, Hinton, and Williams. This algorithm

is based upon supervised training method. Back propagation networks consist of multilayer. Training of a network by back propagation involves 3 steps:

a) Input training data is feed forwarded.

b) The error is calculated and then back propagated to input.

c) The adjustment of weights and biases is done to minimize error.

After training, application of the net involves only the computations of the feed forward phase. So, even if the training process is slow, a trained net can produce its output very rapidly.

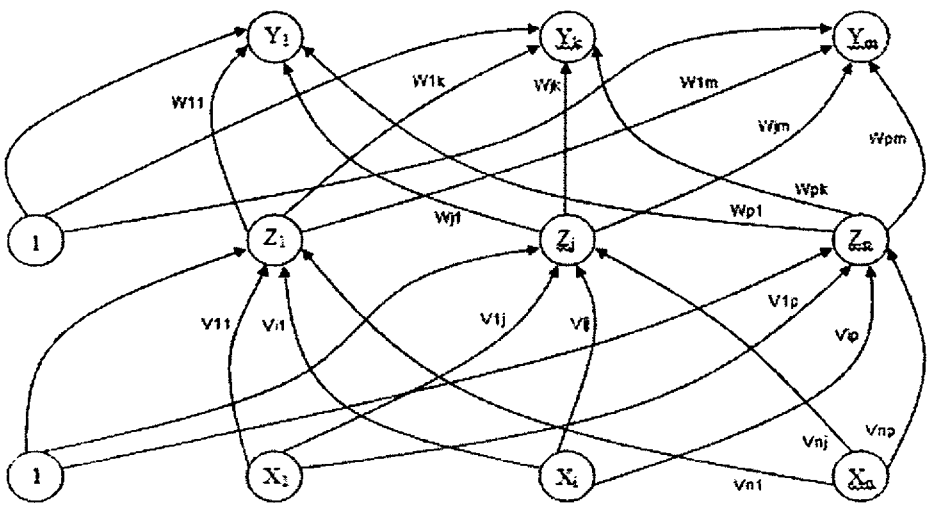

Figure 27-Back propagation Neural Network

Typical back propagation NN with one hidden layer is shown in the Figure below. There are biases on the hidden units and output units. Biases at different units are denoted with different symbols. Bias act like weights and output is always 1.

Neural Net always possesses some 'training' rule, and the weights are adjusted based upon data available.

4.6 Other Networks

Other Networks that exist are given below.

4.6.1 Fixed Networks

In this network, weights cannot beck hanged Weights are fixed keeping the consideration of problem.

4.6.2 Adaptive Networks

Weights are changing in these networks. Adaptive neural networks can be classified in to two categories.

4.6.3 Supervised Learning:

In supervised learning output unit is informed about the desired response. During supervised learning, error is minimized between the desired value and the value calculated. Weights adjustment is done to minimize the error. Least Mean Square (LMS) method is used to minimize the error.

4.6.4 Unsupervised learning

This method is based upon local information's only, external source is not required. This method is based upon Hebbian learning rule. Un-Supervised learning follow on line procedure, it learns and operates at the same time.

4.7 Transfer Functions

There are linear activation functions as well as non linear activation functions. Multilayer's nets usually use nonlinear activation functions. For multilayer net, nonlinear function is used

because if linear is used thenmultilayer behaves like a single layer. Different functions are shown in the fig below.

a) Identity function: $f(x)$

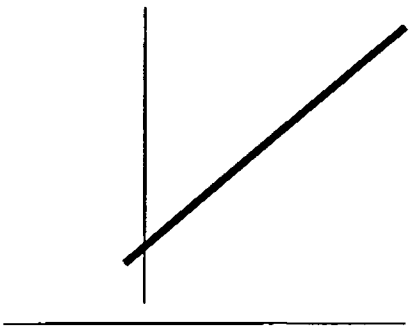

Figure 28-identity function

$$f(x) = x \quad for\ all\ x$$

b) Binary step function :

$f(x)$

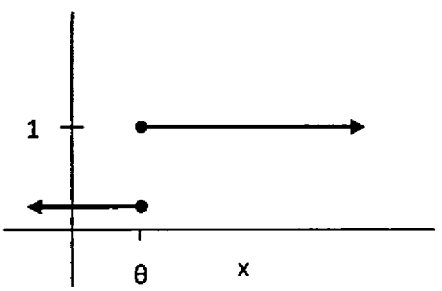

Figure 29-Binary step function

$$f(x) = \begin{cases} 1 & if \quad x > \theta \\ 0 & if \quad x < \theta \end{cases}$$

Binary step function

Binary sigmoid:

$$f(x) = \frac{1}{1+\exp(-\sigma x)}$$

$$f(x) = \sigma f(x)\,[1 - f(x)]$$

Where σ is the steepness parameter. It makes the calculations easy as well as fast.

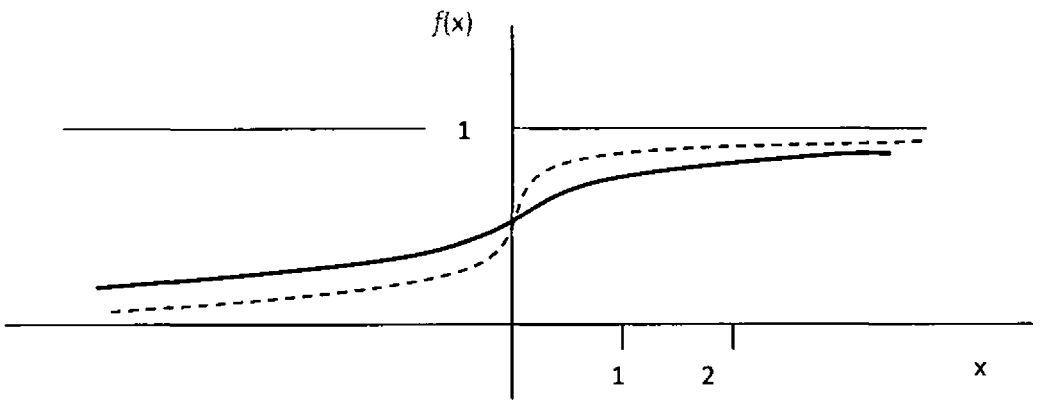

Figure 30-Binary sigmoid

c) Bipolar sigmoid:

$$g(x) = 2f(x) - 1 = \frac{2}{1 = \exp(-\sigma x)} - 1$$

$$g'(x) = \frac{\sigma}{2}[1 + g(x)][1 - g(x)]$$

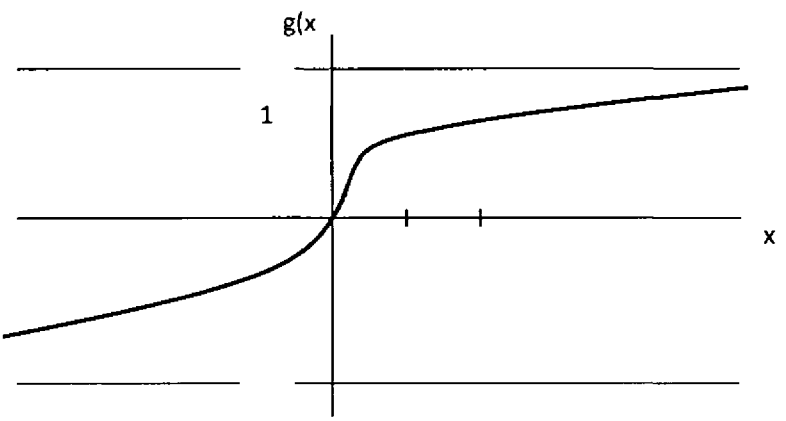

Figure 31-Bipolar sigmoid

4.8 Applications of Neural Network

4.8.1 Neural Networks in Medicine

NN are very useful in medicines and can be extensively used in biological systems such as scanning processes. As NN learn through examples, so the examples are given to NN and then diseases can be recognized.

4.8.2 Modeling and Diagnosing the Cardiovascular System

Human Cardiovascular system can be modeled through Neural Networks. Model of ANN individual Cardiovascular System can be developed and it is compared with the patient model. The difference between healthy Model and patient model can be studied and recorded. ANNs can be used for Sensor fusion Technology. It combines values from different sensors through sensor fusion. ANN learns relationship among the individual sensors values. Data can be fused from Biological sensors, and medical condition is detected.

4.8.3 Marketing

A feed forward network system trained with Back propagation is usually integrated with ATM system to facilitate Airline ticketing and thus help in efficient marketing. Adaptive neural approaches can be used when environment is changing constantly and rapidly.

4.8.4 Credit Evaluation

HNC Neural Systems were developed Robert Hecht-Nielsen and are used by HNC Company.HNC neural nets can also be used for mortgage scanning. Nestor Company also developed a neural network automated mortgage system.

CHAPTER 5

PROPOSED TECHNIQUE AND IMPLEMENTATION DETAILS

5 .1 Database Used

We use Olivetti Research Laboratory (ORL) database available at http: //www.cam orl.co.uk/facedatabase.html. This is a universal database used by many researchers to validate and compare their results. We also used this database to compare and validate our algorithm results. This database i.e. "ORL Database of Faces" contains images of different people which have been taken over a span of two years i.e. from 1992 to 1994 at Olivetti Research Laboratory in Cambridge. The images have variations in facial expression and in facial details (glasses/no glasses). The dataset was used in the background of a face recognition project approved out in partnership with the Speech, Vision and Robotics Group of the prestigious Cambridge University Electrical Engineering Department. The images are gray scale with a resolution of 92x112. We train each network with five images from each subject. We use even numbered images for training. The training phase is further divided into sub phases. We have used 40 different subjects for the evaluation of our algorithm of Multi neural networks. There are ten different images of each of 40 different subjects. For some of the subjects, the images were taken at different times, varying the lighting, facial expressions and facial details of the people. All the images in this dataset of the different subjects were taken against a dark homogeneous background with the subjects in a straight, frontal position. After the acquisition of the subjects, we have stored all the files in BMP format, and can be easily observed on Windows operating systems. In the computer hard disk all the images are organized in 40 directories, where image number for each subject is from 1 to 10.

5.2 Preprocessing

5.2.1 Histogram Equalization

All the input images are having low contrast, so first of all there is a need to enhance the images input for classification. We have used histogram equalization method for contrast enhancement. During this phase all images undertakes the process of Histogram Equalization, improves the contrast of images by converting the values in the input images to a wider range of intensity values i.e. maintaining the same minimum and maximum gray values but grouping them in apart with different gray values.

This histogram equalization method normally changes the local contrast of many images, particularly when the data used is having the low contrast values in the input dataset. The advantage of this method is that all the intensities are adjusted equally and a well-balanced image is obtained. Moreover, this method allows for zones of lower local dissimilarity to gain a higher contrast without altering the intensities values and thus without affecting the overall global contrast in the image. Histogram equalization is one of the methods which achieve this by successfully spreading out the most recurrent intensities of the images under transformation.

Histogram equalization thus offers a more convenient method for adjusting the dynamic range and contrast of an image by altering that image such that its distribution of intensity maintains the required transformed space. The main advantage of this technique is the use of *non-linear* and *non-monotonic* functions to transform the input intensities values to the output space which is different from contrast stretching. In our implementation we have used the Matlab built in function for this operation. The syntax of the function is as image=histeq (image);

5.2.2 Resization

During this phase all images undertakes the process of resizing as required. The size of output image is given to carry out the resizing upon the original image. Image Data is prepared to fit for Neural Network, images obtained has low resolution. This low resolution image is used for faster processing during training & testing phase of the algorithm. Further we have used Bi-cubic interpolation technique to the equalize image to get resize image, the resolution from 92*112 is reduced to 10*10. The preprocessed image is fed to the input of the artificial Neural Network Classifier.

Matlab Function is image=imresize (image, 'bicubic');imresize ( ) function resizes the image as required. The first input argument of the function implies the original image upon which resizing process is applied. The second input argument denotes the size of the output image, and finally the third input argument denotes the method of interpolation used to carry out the resizing upon the original image.

5.2.3 Bicubic Interpolation

The next step after resizing is the interpolation. The interpolation process is used to estimate an image value at a position in between image pixels. For example, if we resize an input image so that it contains more pixels than it did initially, the image processing toolbox utilizes the interpolation to define the values for the extra pixels. In my thesis I have been using the bicubic interpolation processes. Bicubic interpolation is one of the most common interpolation methods in two dimensions. With this bicubic method, the value f(x, y) of a function f at a point (x, y) is calculated as a weighted average of the nearest sixteen pixels in a rectangular grid.

5.2.4 Vectorization

After performing the main pre-processing tasks the next step in the sequence is to put all the images in a matrix, such that a column represents an image data taken from image as each row substituted in to a column and other row data joins the column in the same fashion. Hence at the end we are with a matrix which contains all the images data arranged in columns. This process is known as vectorization. Vectorization can be defined as the process of transforming image data in the form of vectors, as an image data per column and so on. It is used as input to the Neural Network, as NN take input data in the form of vectors [24]. Preprocessed 2-Dimensional image is converted in to 1-D Vector format shown below. Image set (100*200) consists of 200 images because for training purpose even number of images is selected.

5.2.5 Targets

In supervised learning in which targets are provided before to the network in order to make suitable adjustments of weights to achieve the desired output. In this way next step is to make target vector before handing over the images as input to the Neural Network.

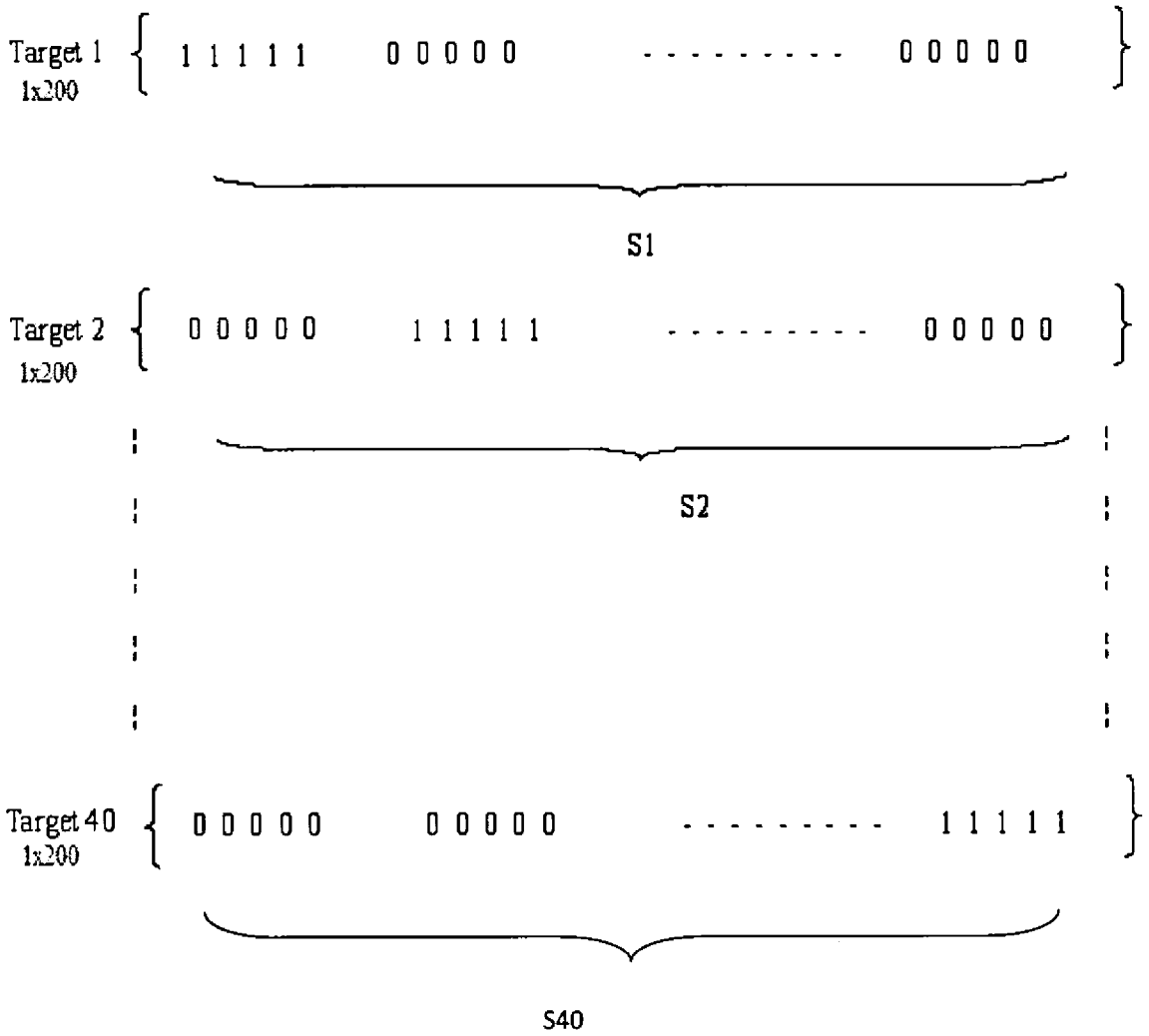

Figure 32 –Targets for individual neural networks

5.3 Multi Neural Network

Multiple Neural Networks consists of 40 Neural Nets i.e. [1 ,2, 3, ----------,39,40] .

5.3.1 Multi Neural Network

The architecture of proposed Multiple Neural Network is based upon the following configuration.

It consists of two layers. Input Layer, single Hidden layer and Output Layer. Preprocessed image in the vector format are presented as input to the Neural Network Architecture which contain 100 neurons in the input layer. This number 100 comes as 10*10= 100. It means the number of input neurons should be equal to total number of pixels in an Image. As in my case the resolution of the image is 10*10 so it got 100 neurons in the input layer. Next is the number of hidden layer neurons used in the network(hidden1). This selection of number of neurons of hidden layer is just like hit and trial. Much different number of neurons is taken in to account for the hidden layer and the best fit with respect to training result is chosen between them. This selection of best fit compromises the efficiency with respect to recognition rate and timing. Hidden or processed layer of this network consists of 9 (hidden) neurons. It contains one neuron as compared to the number of neurons equal to the total number of subjects in. So that after going through the different transfer functions and layer output should be linked to exactly the number of subjects each NN specifying the output with respect to its subjects.

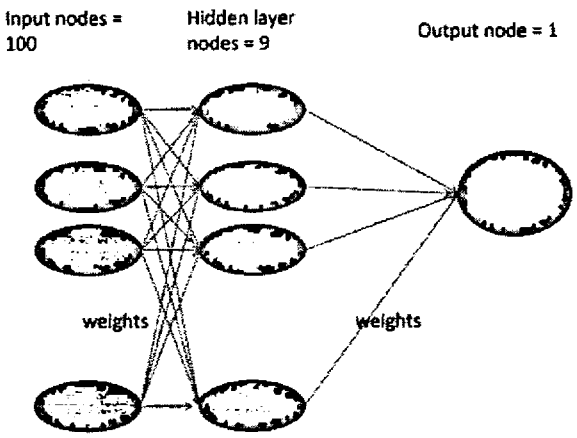

Figure 33: Individual NN for each subject

5.4 Training of Multi Neural Network

The architecture of proposed Multiple Neural Network is based upon single hidden layer, it uses two layers, input, hidden and output layer. We have used 9 neurons in the hidden layer. The reason was we wanted to keep complexity close to that used in. Finally, output layer contains one neuron in our configuration. Algorithm makes efficient use of multiple neural networks 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 does not stick into a shallow local minimum . Neural Network is trained upon even set of images which are 200, and tested upon seen as well as unseen images which are 400 in total. In the proposed methodology neural network utilizes back propagation algorithm for error computation and new weights calculation for each neuron link. The network works through the process of training, continuously in an iterative method it calculates, extracting the mean square error and propagating it backwards if it is not approaching the required targets. Due to this backward error propagation, error-signal for each neuron is calculated and updated accordingly. If the output after the specified iteration or any other approach set by the user approaches the targets then training is considered to be completed. The process of training is shown in Figure 34, below in which training curve is approaching its goal through modification of weights and biases respectively. In the neural network architecture each neuron receives a signal from the neurons in the previous layer, and each of those signals is multiplied by a distinct weight value. At the output of each hidden layer the weighted inputs are summed, and passed through a limiting function which scales the output to a fixed range of values. The output of the limiter is then broadcast to all of the neurons in the next layer. So, to use the network to solve a problem, we apply the input

values to the inputs of the first layer, allow the signals to propagate through the network, and read the output values .

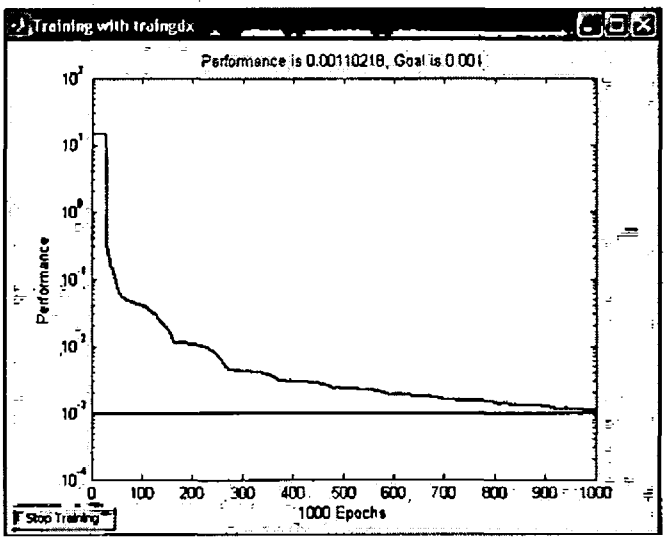

Figure 34-Training graph of Single Neural Network from Multi Neural Network Stage

Transfer functions used are purelin( ), tansig(). Pure Line is also termed as Identity Function. For linear units, the output activity is proportional to the total weighted output. For sigmoid units, the output varies continuously but not linearly as the input changes. Sigmoid units bear a greater resemblance to real neurons than do linear or threshold units, but all three must be considered rough approximations. Training Function, The last input argument to this function for creating neural network is the most important one which is the training function. The training function used in this technique is "traingdx( )". Once the network weights and biases have been initialized, the network is ready for training. During training the weights and biases of the network are iteratively adjusted to minimize the network performance function, net. performFcn. The default performance function for feedforward networks is mean square error mse.It is worth mentioned that with every training there are some default training parameters. Training Parameters, For example net, train Param, show which defines

the output graph should display the output after how much iteration net train Param. Epochsde notes the number of iterations to train the respected network. Net.trainParam.lr depicts the learning rate for the training, mostly its kept constant and is .01in proposed system.

The individual nets have single hidden layer having 9 neurons. The input layer has 100 neurons and the output layer has only one neuron. The neural nets use back propagation to update their weights. The training of the neural nets was done to avoid overfitting by using a small value of error and hence the required number of training epochs could also be kept small. This also reduces the training complexity as compared to other approaches as in [24]. We used only 1000 epochs and the training goal was set to be 0.001 as compared to same values in [24] to be 15000 and 0.00005. Figure (32) shows the targets set for each neural network. The target for each neural net contains 1s for its respective subject images and zeros for the other subject images. We used batch training mode and momentum in the weights update. Figure (34) shows a neural network training curve. The transfer functions used in the feed-forward back propagation neural network are tansig( ) and purelin( ).

5.5 Testing of Multi Neural Network

Testing phase has two sub phases

5.5.1 Multi Net system

A test image is presented to each of the trained neural net from the multi net system. This is the first stage of our face recognition system. The confidence of the first stage is calculated

as

$$cl_1 = 100(1 - P_{21} / P_{11})$$

Here P21 and P11 are the second and first highest values among the 40 neural nets outputs of the first stage, respectively. If the confidence of first stage is higher than a threshold, we decide on the maximum score of the first stage of the multi net system. If the confidence of first stage is lower than a threshold, we take top 10 score classes. We have seen that our correct class is always within this range of the top matches, if not the highest score one.

The top 10 classes proceed to the next stage of phase correlation. Figure (35) shows the output of all nets from the multi net system when the test image is from subject 1. We see that the output of the corresponding net number 1 is well above the outputs of other networks. We next calculate the confidence measure of the second stage.

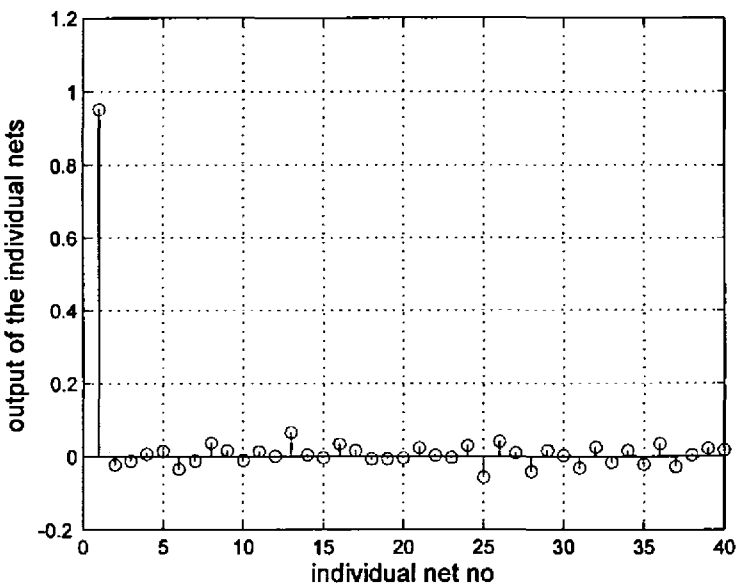

Figure 35: Output of all NNs for a test image of subject # 1. Only corresponding NN has high output

5.6 Conditional Phase Correlation

Second stage of our face recognition system performs Phase Correlation [24b]. Phase correlation is used when speed up in image registration is needed. It has also shown to be robust if the images have non-uniform illumination disturbances or if the images are acquired under varying conditions . Phase correlation in Matlab notation is given by

$$ff = \text{inv fft}(\text{fft}(a).*\text{fft}(b)/|\text{fft}(a).*\text{fft}(b)|)$$

$$score = \max(\max(ff))$$

Here a and b are two face images to be matched. We accumulate the score of test image against the 5 training images of each class which is input to the second stage.

The confidence of the second stage is calculated as

$$cl_2 = 100(1 - P_{22} / P_{12})$$

Here P22 and P12 are the second and first highest (accumulated) scores of the second stage, respectively. If cl2 is higher than cl1, go for the second stage decision otherwise go for the first stage decision. This will make sure that second stage will only change the decision if its confidence is greater than that of the first stage. We have seen that there is an increase in accuracy if we also look at cl2, instead of just going for 2nd stage decision. It has been reported in [24b] that the phase correlation alone has accuracy of 90% for the same database. Our first stage of multi nets has accuracy of 90.5%. Therefore, it seems appropriate to look at the confidence of both the stages for the final face classification. It should be noted that the first stage accuracy is 100% for those test images where we have cl1 greater than the threshold.

By thresholding the first stage confidence for conditional cascading, we have seen that for a threshold of 60, the second stage is omitted 57% of the time, giving much decrease in computational complexity without decrease in accuracy. Of course setting this threshold

offers a tradeoff between the computational complexity and the error rate. If we set threshold too high close to 100, the computations will unnecessarily increase due to inclusion of the second stage. Other the other hand, setting the threshold too low, will decrease the computations by avoiding opting for the second stage but the accuracy will also decrease. We have seen that a threshold of 60 does not decrease our accuracy.

5.7 Results

The authors in [30] used multi net and got accuracy of 97.5%. They had their best result when using input image of size 15 x 15, with 80 neurons in the hidden layer and 40 neurons in the output layer. This amounts to a complexity of (15*15*80+80*40)*40 =848000 multiplications to classify a face. Ours complexity is (10*10*9+9*1)*40 =36360 while our accuracy is 99%. This shows a complexity advantage ratio of more than 68. Though, we are using phase correlation in the testing phase, the phase correlation is used only 43% of the times so our total complexity is always lower than that of [30]. The testing phase of [30] also involves calculating (15*15*40 = 9000) Euclidean distances to classify a face while our classification does not involve such calculations. Their nets are not trained on imposter images and it seems that their NNs are redundant as we could very easily calculate 9000 Euclidean distances from the mean images of each class and classify the face without even using the NNs.

A single neural network was used by [24] for face recognition. The work in [24] was extended by using cascading with phase correlation by [24b]. For face recognition [30] suggested training a dedicated neural network for each subject. Each subject's network was trained by setting the same subject pixel values as its output. Therefore, their target of the individual net for each training image of the same subject will change. They train individual nets by showing only the image of that particular subject. We argue that our training of

neural nets based on genuine as well as imposters is more intuitive as detailed in the training section above. In [31], face recognition using multi neural nets is discussed. We could not get this paper to comment on its training procedures.

Our approach differs from [30] in that we train a neural network for an individual by showing its own as well as imposter images. Though our approach necessitates training each network whenever a new subject is added to the database. This extra complexity as compared to the technique in [10] can be justified as training is performed offline. In addition, as we use a very small number of neurons in each net, hence, the overall complexity of training also remains comparable. Our approach differs from [24b] in that we do conditional cascading as well as introduce confidences. The conditional cascading is more intelligent as it reduces the computational complexity and at the same time gives good accuracy.

CHAPTER 6

CONCLUSION AND FUTURE WORK

6.1 Conclusions

Multiple neural networks have been used in bio-metric applications mostly to form an ensemble of classifiers for boosting or for using them as mixture of experts. Training a dedicated network for each subject has been previously suggested in few of the papers on face recognition. The training was not intuitive and/or the complexity increase problem was not handled. In our approach, each neural network is shown not only its own subject images but also those of other subjects. We show better accuracy and at the same keep the computational complexity of training and testing phases low by using a very few number of neurons. Our approach is so rich that we get better accuracy using only 0.6 times the image resolution as compared to other multi net approaches. This makes our application useful in scenarios where high resolution face images are not possible to acquire e.g., in surveillance applications. We cascade first stage of the multi nets with a second phase correlation stage. We reduce the search space for the second stage by giving only top 10 matches from the first stage. We also propose a novel cascading algorithm. The algorithm calculates a confidence measure based on results of the first stage and classification opts for the second stage only if the confidence measure is below a threshold. Furthermore, the decision of the second stage is kept only if the confidence of the second stage is higher than that of the first stage; otherwise decision of the first stage is kept intact. This conditional cascading not only improves accuracy of the overall face recognition system but also reduces the complexity.

The conditional cascading makes our cascaded face recognition system more intelligent and we have seen that it further reduces complexity by 57% by avoiding the phase correlations when it is not necessary to do so. The threshold set, of course, sets a compromise between accuracy and reduction in complexity.

6.2 Future Work

- A future direction would be to make the number of inputs to the second stage adaptive by looking at the score distribution of the first stage. It will further reduce computations.
- We should note that the conditional cascading approach, we propose, is also applicable to any cascading scenario. The use of confidence measures is very intuitive and improves on accuracy as well as computational requirements.
- Our proposed technique can be extended to imposter testing. Another future direction would be to base imposter testing on the confidence measure. The confidence measures of both stages will be low for an imposter.
- The complexity of the proposed cascading approach can be further reduced by training a MACE filter [29] for each subject and replacing phase correlation of second stage with the matching of only one MACE filter per subject.

References

[1] A. K. Jain, J. Mao, and K. M. Mohiuddin, "Artificial Neural Networks: A Tutorial," *IEEE Computer*, 29(3), pp. 56-63, March 1996.

[2] A. K. Jain and J. Mao, "Neural Networks and Pattern Recognition," *in Computational Intelligencefor Imitating life,* J. M. Zurada, R. J. Marks and C. J. Robinson (eds.), IEEE press, pp.194-212, 1994.

[3] W. Zhao, R. Chellapa, P. J. Phillips, and A. Rosenfeld, "Face Recognition: A literature Survey,''Technical Report CAR-TR-948. Center for Automatic Research, University of Maryland.*ACM Computing Surveys,* Vol. 35, No. 4, December 2003, pp. 399–458.

[4] S. Buchala, N. Davey, T. M. Gale, and R.J. Frank, "Analysis of Linear and Nonlinear Dimensionality Reduction Methods for Gender Classification of Face Images, *"International Journal of System Science,* Vol. X, No. X, Month 2005, xxx–xxx.

[5] D. Kidner, M. Dorey, and D. Smith, "What's the point? Interpolation and extrapolation with a regular grid," DEM. IV *International Conference on GeoComputation,* Fredericksburg, VA, USA, pp.81-112, 1999.

[6] M. Turk and A. Pentland, "Eigenfaces for Recognition". *Journal of Cognitive Neuroscience*, Vol.3, No.1, pp. 71-86, 1991.

[7] P. Temdee, D. Khawparisuth and K. Chamnongthai, "Face Recognition by Using Fractal Encoding and Backpropagation Neural Network," *Fifth International Symposium on Signal Processing and its Applications*, ISSPA '99, Brisbane, Australia, pp. 159-161, August 1999.

[8] M. M. Khan, M. Y. Javed, and M. A. Anjum, "Face Recognition using Sub-Holistic PCA", Information and communication technologies, ICICT Pakistan, pp.152-157, August 2005.

[9] www.biometrics.gov

[10]LaureneFausett, FloridaInstitute of Technology, Fundamental of Neural Networks (Architecture, Algorithms, and Application), 2008, Pearson Education, Inc, Head Office: 482, F.I.E., Patparganj, Delhi 110 092, India.

[11] http:// www.emsl.pnl.gov.2080/doc/cie/neural/neural.homepage.html

[12] M. A. Grudin, "On Internal Representations in Face Recognition Systems," *Pattern Recognition*, vol.33, no.7, pp.1161-1177, July 2000.

[13]M.TurkandA.Pentland, "Eigenfaces for recognition," Journal of Cognitive Neuroscience, vol. 3, no. 1, pp. 71–86, Mar.

1991.

[14] M.S.Bartlett,H.M.Lades, andT.J. Sejnowski, "IndependentComponent representations for face recognition," in Proceedings of the SPIE, 1998, vol. 3299, pp. 528–539.

[15] M. A. Anjum, M. Y. Javed, and A. Basit, " Face Recognition using Double Dimension Reduction" proceeding of World Academy of Science, Engineering and Technology 4 2005.

[16] A. HosseinSahoolizadeh, B. ZarghamHeidari, and C.HamidDehghani, "A new Face Recognition Method using PCA, LDA and Neural Network," International *Journal Of Computer Science and Engineering* 2:4 2008.

[17] Ki-Chung Chung,SeokCheolKee, and Sang Ryong Kim HCI Lab., Samsung Advanced Institute of Technology , San 14, Nongseo-Ri, Kiheung-Eup, Yongin City, Kyungki-Do,

vol. 2, no. 2, pp. 42{47, July 2008.

[25] Stan z.li and Anil K.Jain ,*Handbook Of Face Recognition. 2005,* Springer Science +Buisness Media, Inc,233 Spring Street, New York, NY 10013,USA.

[26] Shang-Hung Lin,"An Introduction to face Recognition Technology," *Information Science Special Issue on Multimedia Information Technologies*-Part2 Volume 3 No 1.2000.

[27] Keys, R. , "Cubic Convolution Interpolation for Digital Image Processing" , *IEEE Trans on ASSP* ,vol ASSP-29, No.6, DEC 1981.

[28]U Qayyum, "Efficiency Enhancement of Neural Network with Phase Only Correlation,"*International Journal of Digital Content Technology and its Applications*Vol. 2 No 2, July 2008

[29] V. Kumar, M. Savvdes, and C. Xie,"Correlation Pattern Recognition for Face Recognition," *Proceedings of the IEEE*, Vol. 94, No. 11, November 2006

[30] A. Merrad and N. Golea, "Multi-Layer Perceptrons Approach to Human Face Recognition," *J. Automation & Systems Engineering*, vol. 4-3, pp. 165-172, 2010.

[31] R. Chang and E. Para, " Reconnaissance de visages par rseaux de neurones," in *Rapport de stage, Universit Pierre et Marie Curie, Laboratoire d'Instruments et systmes d'lle de France, Juillet.* 2003.