IRIS RECOGNITION USING ARTIFICIAL NEURAL NETWORKS AND BACK PROPAGATION

A THESIS SUBMITTED TO THE GRADUATE SCHOOL OF APPLIED SCIENCES OF NEAR EAST UNIVERSITY

By
MAHMOUD.M. TARHOUNI

In Partial Fulfilment of the Requirements for the Degree of Master of Science in Electrical and Electronic Engineering

NICOSIA, 2019

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Approval of Director of Graduate School of
Applied Science

Prof. Dr. Nadire ÇAVUŞ

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last name:

Signature:

Date:

To my parents and family….

ACKNOWLEDGMENTS

I would like to express my deepest thanks and sincere appreciation to my supervisor in this work, Assoc. Prof. Dr. Kamil DIMILILER; who was my motivator during the work of this modest thesis. It is time to thank him for all his patience and guidance throughout all my study for my master degree. Prof. Dimililer's knowledge and critics were very important to put me on the right way and to enlighten my ideas and inspired me with new thinking manner. My deepest gratefulness is expressed also to all my family members, and my wife who was my great fan and supporter. I will always be grateful to my dear friends, colleagues, and the Libyan community in the TRNC.

ABSTRACT

Biometric identification system is one of the most important rapidly growing technologies in today worlds; this promising technology has been most attractive for researchers in scientific fields and has become widely used in many different areas such as security systems, secure financial transactions, credit-card authentication, and premises access control.

In today's information technology world the Iris recognition is considered as one of the most effective methods of authentication and identification of biometric identification systems in corporate worlds thanks to the unique characteristics of human iris.

This work will illustrate the importance of human iris recognition and the most common aapplications of this technology, it will also provide the digital image processing techniques that contribute effectively to improving the quality of system performance. In this work artificial neural network with Back-propagation algorithm as a learning algorithm will be used for the detection and person identification based on the iris images of different people, these images will be collected in different conditions and groups for the training and test of ANN. Finally all practical works and results will be presented and discussed with images, moreover, the behavior comparison and performance evaluation of changing the parameters of the neural network in the proposed system will be present using MATLAB environment.

Keywords: Artificial networks; back propagation; biometrics; iris recognition; iris

ÖZET

Günümüzde biyometrik kimlik saptama sistemi hızla gelişen en önemli teknolojik sistemlerden bir tancsidir. Bu ilerisi için báşarı vadeden sistem bilimsel alanlarda çalışma yapan araştırmacılara çok cazip gelmeiş ve halen güvenlik sistemleri, güvenli para aktarmaları, kredi kartlarının güvenliği(sahte olup olmadıkları), ve konutlara giriş kontrolleri gibi bir çok alanda kullanılmaktadır.

Günümüz bilgi teknolojisi dünyasında lris gerçeği, işbirliği icinde olan ülkelerde belgeleme ve biometrik kimlik saptama sistemlerinde en etkili metotlardan birisidir.

Bu çalışma, insanlara iris gerçeğinin önemini ve bu teknolojinin en yaygın uygulanmalarını anlatmaktadır. Bu çalişma ayni zamanda, sistem pefrormans kalitesinin gelişmesine olumlu katkı sağlayan dijital imaj sürecini de ele almaktadır. Bu çalişmada, yayınımlı oğrenim algoritması olan sinir ağı, farklı insanlarin lrs Imajina dayalı tespit ve kişisel kimlik saptamaları için de kullanılacaktır. Bu imajlar farklı durumlardan ve grplardan eğitim ve ANN testi için toplanacaktır.

Sonuç olarak, bütün pratik çalışmalar ve sonuçlar sunulup imajlarla tartışılacaktır. Dahası, MATLAB ortamında, davranış karşılaştirması ve öngörülen sistemde sinir ağı parametrelerinin değişim değerlendirmeleri de sunulacaktır

Anahtar kelimeler: Yapay sinir ağlar, geri yayınımlı, biyometrik, iris gerçeği

TABLE OF CONTENTS

CHAPTER 4: ARTIFICIAL NEURAL NETWORKS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ANN: Artificial Neural Network

CNN: Convolution Neural Networks

MSE: Mean Squared Error

DLNN: Two Step Learning Neural Network

CHAPTER 1

INTRODUCTION

1.1 Introduction

Biometrics is one of the most important rapidly growing technology in the fields of public and information security. Biometrics uses different physical and behavior characteristics of person like face details, finger-print, eye retina, IRIS, ear, and signature. Biometric features are known to be accurate and unique. They have the ability to identify individuals and to distinguish different people (H.Abiyev; & A., 2008)**.** Biometrics is the science that studies of the different methods applied to measure physical and behavioral characteristics of individuals. These characteristics can be used to identify the individual in a unique manner (Abiyev & Altunkaya, 2007). Physical biometrics based on face recognition, eye print, finger print, and voice recognition are common as they are simpler to determine than behavioral characters such as handwriting and type of printing (Alheeti, 2011).

The researches on biometrics are taking a lot of interest from researchers and scientists due to its high importance in security and safety systems and the increasing needs for more and more secure and easy recognition methods. The use of cards with long difficult passwords represent a big challenge for a lot of people who face difficulties in remembering their bank accounts, credit cards, even their own computers passwords. The revolution which happened in the digital technology has encouraged researchers to make advanced steps in biometrics. The day life use of digital recognition systems based on biometrics became a reality (Daugman, 2004).

There are two distinct methods in biometrics, the first is physical biometrics like face ear, and eye, the second is behavior biometric methods like printing type, walk rhythm, or signature shape. Applications of biometric traits are more common in security applications, medical centers, banks, and military areas. They are used in fields involving fingerprint recognition, face recognition, iris recognition, and gate access control. These biometric signs have been most attractive for researchers in different field of science (Neha, Gupta, & Mahajan, 2010).

The use of face features in person’s recognition has started early. Many researches were carried out in face recognition, ear recognition, eye retina recognition, and IRIS recognition. These researches used different approaches to extract the important distinct features of a person. By using these features with the help of efficient DSP computers, the recognition of persons has become feasible and easy. IRIS recognition is one of the important biometric recognition approaches. It has become one of the main active topics in research and practical applications (Neha et al., 2010).

Artificial neural networks has become very famous and applied in many aspects of science. It is using mathematical equations and formulas to simulate the function and structure of the brain. Artificial neural networks and back propagation algorithm have been used widely in biometrics. The use of artificial neural network in face and iris in addition to fingerprint recognition has been introduced in many researches. Neural networks are extremely parallel computing networks built of a hundreds of small processors totally interconnected.

The idea of neural network is useful for function approximation where the networks try to behave the same way the function behaves. The interconnections in the neural network change slightly according to predefined criterions until the find an optimum structure. The optimum solution is able then to produce the desired output from the given input. The performance of the network is increased during the training by continuously updating the weights of the network. The network is expected to be able to generate a correct output when a new set of inputs is presented. The training of ANN to perform a task implies the use of sets of inputs and targets. These sets are considered as examples for teaching the networks. The internal connections of the network are modified iteratively until finding the optimum values that approximate the best our input output relationship.

The proposed work will discuss the use of artificial neural networks in biometric systems. The IRIS recognition has been specifically chosen to be performed using back-propagation neural networks. IRIS pictures of different people will be collected in different conditions and groups for the training and test of ANN.

1.2 Literature Review

The use of IRIS has been introduced and mentioned since a long time in different sources. Many different extraction and recognition methods have been mentioned and used in literature using IRIS characteristics. Researchers agree that IRIS is a unique feature to be used in biometrics. The use of ANN for IRIS recognition system for practical applications has been introduced and discussed in (H.Abiyev; & A., 2008)

The use of wavelets and image processing techniques for IRIS recognition was introduced in (Alheeti, 2011). Different edge detection methods like Canny, Prewitt, Roberts and Sobel filters are implemented to extract iris boundaries in the eyes image. (Al-mashahadany, 2010) has discussed the use of IRIS as biometric with different digital image processing techniques and ELMAN artificial neural networks. Discussion about the techniques used for IRIS recognition was presented in (Daugman, 2004).

IRIS recognition system based on different DIP techniques was proposed in (Neha et al., 2010). Artificial neural networks system was proposed in this paper for IRIS recognition. IRIS biometrics recognition for person identification in security systems was discussed by (Roselin.E.Chirchi, L.M.Waghmare, & E.R.Chirchi, 2011).

CHAPTER 2

HUMAN IRIS IN BIOMETRICS

2.1 Introduction

In today worlds, the iris became a much explored field which plays an important role in biometric identification system in order to distinguish the individuals from each other. This chapter will provide a general overview of biometric identification system and human iris recognition specifically. Moreover, this chapter will illustrate the importance of human iris recognition in the field of recognition and security in addition to the reasons that made the human iris one of the most effective methods in biometric identification system.

2.2 Biometric Identification System

In science the term of biometric refers to metrics related to human characteristics, while in technical science the term of biometric system can be defined as the system which uses the unique biological organism of the human in order to achieve many tasks such as biometrics authentication, biometric identifiers, surveillance and access control .

In today worlds, the biometric identification system is becoming common. however, this systems use different behavioural characteristic (which are related to the pattern of behaviour of a person) or psychological characteristics (which are related to the shape of the of human) such as finger, face, iris or signature, speech and walking style for identification purpose .However, this features which are used in the biometric identification system must be subject to the strict standards such as universality, distinctiveness permanence and collectability, the following section will present the definition of these terms.

2.2.1 Universality

In biometric identification system the term of university is mean that every individual should have unrivalled characteristics. This factor applies to many of the human characteristic that exist in humans such as the eyes or ears, while the availability of glasses cannot be considered a unrivalled characteristics and therefore can’t be used at this biometric authentication. Systems.

2.2.2 Distinctiveness

This factor is mean that the feature which will be used in the biometric identification system must has a highly different texture and features from one person to other, and this is what is already available in the iris in humans. The iris differs in its texture and characteristics from person to person, so there can’t be two people with two identical iris even in twins. The figure bellow illustrate different human eyes with different types of iris.

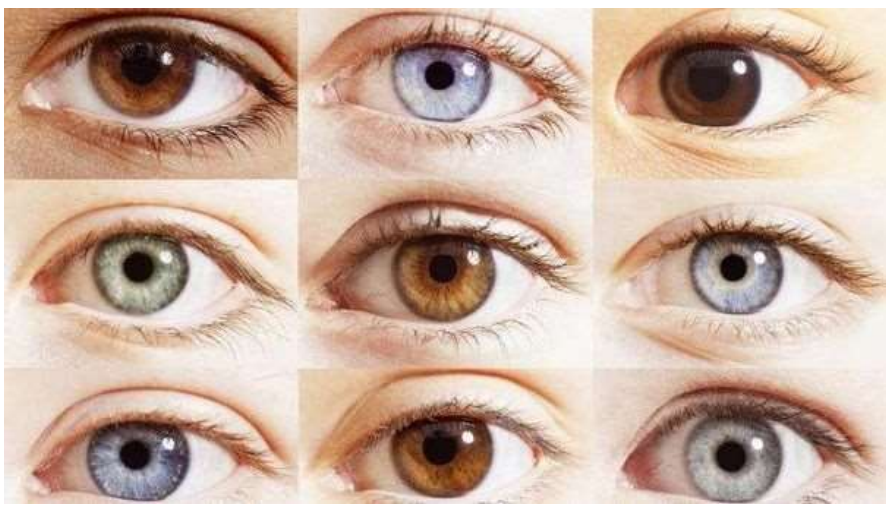


Figure 2.1: Different human iris colours

2.2.3 Permanence

This criterion is meant that when the human physical characteristic is selected for the identification system, this characteristic must be stable and unchangeable. There are many psychological characteristics which have the required factors that determine the selection rules of psychological characteristics in biometric identification system, but because of the possibility of changing in these characteristic from the surrounding conditions or with the aging of the human being, these psychological characteristics become ineffective in the process of recognition of the use of the intruder intelligent.

2.2.4 Measurability

In order to use the human characteristics in digital processing operations and in intelligent systems that use many algorithms, these characteristics must be measurable in order to acquired data in appropriate form for processing operations. However, human iris is a good example for measurable characterises which can be used in biometric identification system.

2.3 Human Eye Anatomy

The human eye is a sense organ which reacts to light and pressure, this organ helps to provide a three dimensional vision, the eye has a number of components shown in Figure 2.2, these parts are the Iris, pupil, cornea, lenses, and optic nerves. However this section will focus on the iris and iris recognition system.

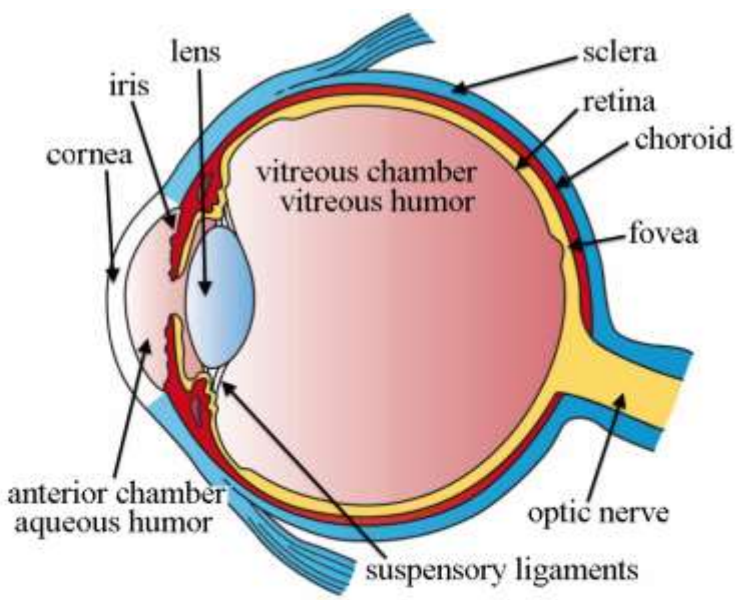


Figure 2.2: Human eye anatomy (Tori, 2016)

The main task of the sclera is to provide protection of eyeball , another important part in human eye is the pupil which is appear as black hole in the centre, this part allows the light to cross from the outside into the inside of the eye. The amount of lighting entering the eye can be controlled by another member named the iris which is has the ability to change the pupil size, the human iris can be distinguished as it looks coloured in some people. The part that provides protection for iris and pupil is called cornea. In the previous figure the lens appears in the front of the eye where it plays an active role in the process of vision through shedding the lighting on the retina then the retina different turn the light into electrical impulses.

In order to add more information about the human iris, which will be the cornerstone of this work, Figure 2.3 shows the iris anatomy in human eye that can be defined as the plane circular crust behind the eye cornea, iris has the ability to control the size and diameter of the eye pupil. This structure gives the colour for the individual eyes. The iris and pupil are very useful in controlling the light intensity that enters the eye and reaches the retina. In other word, the iris muscles behaves to minimize the eye pupil whenever too much light is focused in; and broaden the pupil if smaller amount of light is available. Generally, the iris is composed of two main areas: the area that surrounds the pupil and the other area that expands to the ciliary body.

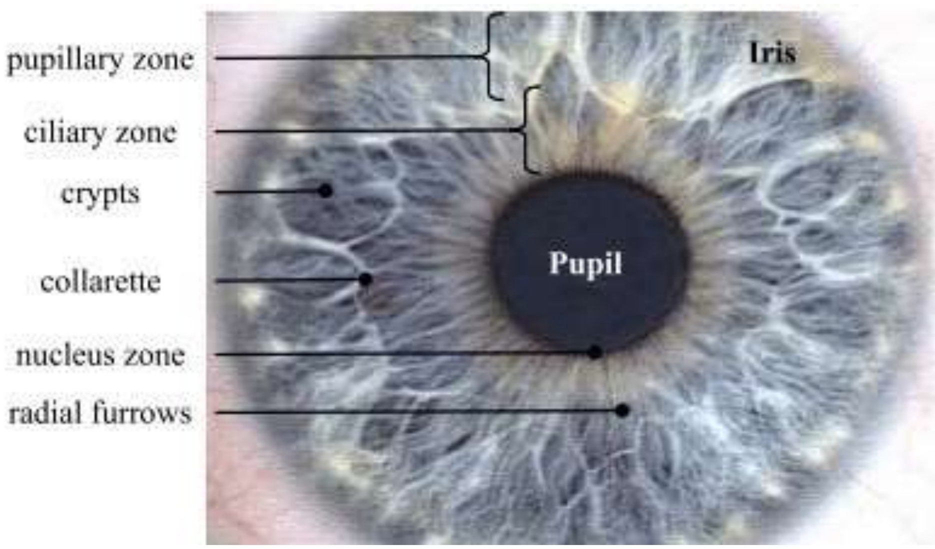


Figure 2.3: Human iris feature

2.4 Human IRIS Recognition

In the biometric identification system iris recognition is refers to the automated method of biometric identification that uses pattern-recognition techniques based on high resolution images of the irises of an individual's eyes. However, among the many features that are used in recognition systems, iris recognition systems are considered to be systems that are characterized by accuracy and high efficiency because of the fact that the iris in human eye is subjected to many criteria in the biometric identification systems.in other words, the iris of the eye is characterized by exclusivity so that the iris cannot be similar between two persons even in the case of twins, in additional the iris has highly different texture and features making the iris recognition system considered as a highly effective system in many application .Moreover, iris pattern are stability which is mean that it remains unchanged with the age or surrounding environment.

Iris recognition technology is now widely accepted in many industries for authenticating legitimate users as a biometric system which can be used to identify a person by analysing the patterns found in the iris and has many applications in the field of security systems, secure financial transactions, credit-card authentication, premises access control and physical access control in private enterprise and government.

Biometric identification system is a promising technique which has many applications in various areas of life for example, it is common in system security, online banking, cell phones, credit card applications, building access systems, airport security systems, health services and social media. However, these applications rely on using database with programs searching for specified results, they generally relate to a positive identification of a user or other individual.

CHAPTER 3

DIGITAL IMAGE PROCESSING

3.1 INTRODUCTION

Image processing is an effective method to accomplish some tasks on an image, this operation has the ability to improve the image or to extract information from the images. In this operation which is considered as a kind of signal processing, the image represent the input of the system while features represent the output that associated with image.

In this chapter the basic image processing techniques used in this work will be discussed, such as filtering, segmentation and image normalization. Eventually, this chapter will provide the flow chart of the structure for the proposed work.

3.2 Digital Image Processing Preview

Historically it can be said that the development of digital image processing technology was in 1960s at the Jet Propulsion Laboratory. In the 1970s with the development of computers in term of efficiency in addition to the availability of affordable prices, the digital image processing technology has begun to spread widely. In the 2000s, digital image processing has become one of the important forms of image processing techniques because this technology is one of the most efficient and cheapest methods (Gonzalez & Woods, 2001).

Image digital processing can be considered a sub-domain for signal digital processing which input is an image and output may be image or features associated with that image. However, digital image processing can be defined as effective way to perform many operations on the images in order to improve or extract information from them.

To start from the main stone in this subject must be to recognize the concept of digital image first which is a digital image, in technical terms the image is typically refer to raster images or bitmapped images in other word the digital image is an picture represented digitally in groups of combinations bits(0 or 1) called pixels. When we apply computer algorithms to images in order to change the order of pixels or to improve the quality of images, this process is called digital image processing.

Digital image processing has an increasingly significant function in an extensive diversity of fields in science and technology such as TV's, automatic character recognition, robotics, photography, pattern recognition, medical purposes and manufacturing process assessment.

3.3 Image representation

A digital image is a binary representation (a binary value of zero and one) of a material object that can be seen by the human eye which is entered by the digital camera or scanner to the computer for modification or storage purpose.

The computer converts the normal image into a digital image by means of the sampling process, these small sample is called one pixel, it can be said that the image is represented in the form of an array of pixels where this pixel takes a specified value and occupies a one bits of memory storage. However the digital image can be represented in 3 main ways:

3.3.1 Binary image

In this way the pixel has a binary value of either one or zero. When the value of pixel is one that reflects the white color, while the value of zero is reflects the black. Thus, the digital image will appear in only two colors, black and white as shown in the **Figure 3.1** below.

Figure 3.1: Binary image representation

3.3.2 Grey-scale image

In this way, the pixel places a space in the memory 8 bit and takes a value from 0 to 225(2^{8bit}), these values reflect the gradient from white to black through different gray-scale, For example, when the pixel takes the value of 5, it means that the color is gray close to the black color while the value 240 represents the gray which is close to the white color, the **Figure 3.2** shows a digital image represented by Grey-scale method.

Figure 3.2: Gray scale image representation

3.3.3 Color image

This system depends on the different grades of the three main colours RGB (Red-Green-Blue). The digital image is expressed in a 3D matrix, each pixel takes three values, each value representing a degree of basic colour, by combining the three possibilities we can get a certain color, through this process the digital coloured image is represented as shown in the **Figure 3.3**.

Figure 3.3: RGB image representation

3.4 Digital image processing techniques

In digital image processing the image need usually to be treated first in many practical applications and smart systems using many techniques that help to improve the quality of images and make them suitable for the advanced stages of work. In the next section we will present the most important techniques used in digital image processing.

3.4.1 Image filtering

In the field of digital image processing, many images need a modification and optimization process, and sometimes specific techniques for removing some features or emphasize some other features, these processing operations can be done using the so-called image filtering.

An image can be filtered in order to improve the detectability of important image details or objects; this enhancement operation includes smoothing, noise reduction, sharpening, and edge enhancement. In other words, the filter process depends on applying algorithms to the values of the surrounding pixels of the corresponding pixel in order to expect its best fit value in the resulting image. There are many famous filters in the field of image processing. We will provide a general overview in the following sections about Weiner and Madian filters.

3.4.1.1 Wiener filter

Wiener filter is a type of the adaptive frequency domain filters that was proposed by Norbert Wiener in 1940, this type r uses a pixel wise adaptive Wiener method uses statistics data from the pixel neighbourhood. In general, the principle of its work is based on comparing the received signal with an estimation of a desired noiseless signal in order to enhance degraded images and noise, assuming known stationary signal and noise spectra, and additive noise. This filter is considered as stationary linear filter based on minimize the mean square error between the image and an estimate (Mohan, Mridula, & Mohanan, 2016).

Since Wiener filter is a type of the frequency domain filters which is applied on the discrete Fourier transform of an image and require working in the frequency domain, it can be said that Wiener filters are relatively time-consuming filters when applied, since they need to be applied in the frequency domain. **Figure 3.4** presents a sample of the original, noisy, and the picture after applying Wiener adaptive filter for gray scale image.

Figure 3.4: Reducing the noise from gray scale image using Wiener filter

3.4.1.2 Median filter

Median filter is a is a spatial nonlinear filter which is used in digital image processing, the digital image can be seen as consisting of small squares called pixels, each of these pixel holds a number that symbolizes a particular color in a particular color scheme. However, the Median filter is an effective method that based on the process of scanning the image pixels; The algorithm of median filter is applied to every pixel of the desired image. Each pixel of this image is replaced by the value of the median of its surrounding area. This median is found by arranging all the surrounding pixel values increasingly, and then finding their statistical median (Hu & Wang, 2017). **Figure 3.5** illustrates the filtered image after applying median filter for blurred image.

In general, it is clear that there is a difference between filters in terms of the linearity and filters domain, since Median filter is a is a spatial nonlinear filter while Wiener filter is a type of the nonlinear frequency domain filters, however, Median filtering was capable to enhance the intensity at a given point in the respective image. Wiener filtering served to enhance the pixels values and the intensity values of the image.

Figure 3.5: Reducing the noise from gray scale image using median filter

3.5 Image segmentation

In computer information science, the term image segmentation is refers to the process of partitioning a digital image into multiple segments which are known as sets or pixels based on a discontinuity or a similarity criterion, with applying this technique the image will be represented into set of segments that collectively cover the entire image, in addition the result of image segmentation might be represented into a set of contours extracted from the image. However, the purpose of this operation is to simplify and change the representation of an image into something in order to make it more meaningful and easier to analyze (Hodneland, 2003).

Typically, the process of segmentation the image is depends on the dependence of the pixels within the group in terms of texture, color, or intensity. This technique is an important part of the image processing in the applications of recognition, because it helps in reducing the amount of details in the image that are not important for the recognition system (Bengaluru, 2016).

There are many methods used in image segmentation process according to the application, the most famous methods are: Pixel-based segmentation, edge-based segmentations and region-based segmentations.

3.5.1 Segmentation

The main objective of this segmentation type of is to divide the pixels into categories based on its intensity level, this simplest and the most popular method depends on threshold value in order to take the appropriate decision to segment and divide the pixels in image which is mainly used to distinguish the foreground objects from background in image processing. Mathematically all Pixels are allocated to categories according to the range of values. However, the value of threshold be determined either by an interactive way or can be the outcome of automatic threshold selection method. The Figure 3.6 illustrate the simplest thresholuding methods which is replacing each pixel in an image with a white pixel if the image intensity is greater than threshold value T, while if the intensity of the pixels is greater than T, then these pixels are replaced by black pixels.

Figure 3.6: Image segmentation

3.5.2 Edge-based segmentations

An edge detection algorithm used in image processing, image pixels are sorted into edges and details based on the output from the algorithm or filter. **Figure 3.7** below shows the limits or borders of regions after the application of Prewitt filter and rejecting all normal segments.

Figure 3.7: Edge based image segmentation

3.6 Image normalization

In order to fit the neural network implementation process, the images of database must be processed before starting training the network where ANN deals better with the absolute value less than 1. One of these processes is image normalization which is changes the range of pixel intensity values to avoid long training time or fail convergence toward the goal error. This step plays a very important role in the implementation .Since the the images used are 8 bit images, and then each pixel could be represented as a concentration value between 0 and 255.

After finishing all operations on images such as using filters, then the process of image normalization is applied. In this step the used training and testing images will be normalized by applying the normalization formula on each image are then fed to the neural network in double format for better results. The formula of 8bit image that is used can be expressed as follows:

$$Normalized\ image = double(image)/255 \tag{3.1}$$

3.7 Structure of Proposed Iris Recognition System

After normalizing all the images, each one of the images will be converted to a vector by arranging image columns in one dimensional column. The new vector is going to be assembled with all other image vectors preparing to be submitted to the network structure. The images will be fed to the network in the form of one grand matrix that will contain all training images. Practical application of the ANN on the processed images in addition to the results will be discussed later in this thesis work.

The IRIS database images was collected from the iris database directory UBIRIS in the University of Beira. The database contains 804 different iris images collected from 79 persons. We are going to use this database for the study of the iris recognition using artificial neural network. The recognition task is going to be implemented as follows:

1- Reading all IRIS images in jpg format
2- Converting all RGB images to gray scale images
3- Filtering all the images using Wiener filter to remove possible noise
4- Resizing all images to small size to be suitable for artificial neural network applications
5- Apply averaging windows on the images (for size reduction process)
6- Apply normalization process on the image pixels
7- Convert images to vectors to be given to the neural network
8- Built structure of the artificial network
9- Start training of the neural network
10- Save all parameters
11- Apply test of neural networks
12- Check the results and do the required modifications

These steps can be summarized in the next flowchart

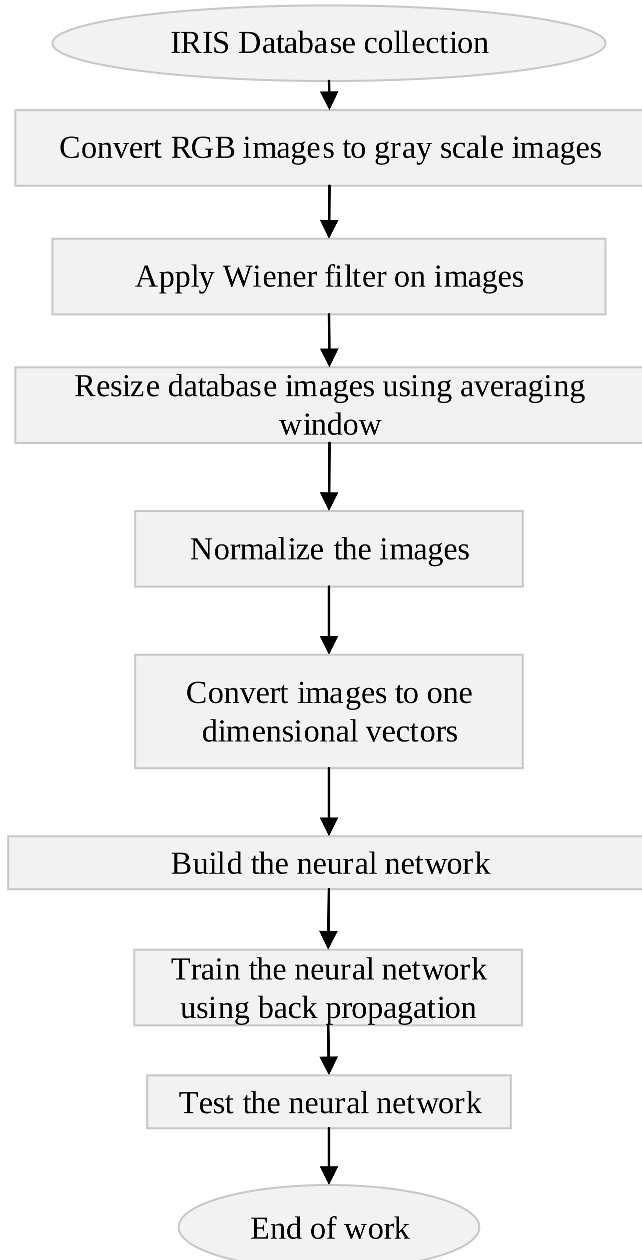


Figure 3.8: Block diagram of the proposed IRIS recognition system

CHAPTER 4

ARTIFICIAL NEURAL NETWORKS

4.1 Introduction

Recent years have seen significant developments in the field of technology and its applications, artificial neural networks is among the most powerful expertise in the last 21^{st} century which has been widely used in a different areas in real life.

This chapter will provide a general idea about the artificial neural networks, the structure, categories and the main types of learning algorithms.

Different Transfer functions of ANNs will be discussed as well.

Eventually, this chapter will provide an overview of the most common areas of artificial neural network applications.

4.2 Historical Overview of Artificial Neural Networks

In general, the artificial networks inspired by the neural networks of the human nervous system are called the Artificial Neural Networks; artificial networks have proven to be an effective tool to perform many tasks such as clustering, classification, and pattern recognition (Colin, 1996).

Historically it can be said that artificial neural networks appeared in the 5th decade of the 20th century, McCuloch and Pitts are considered the first researchers to publish a paper in this area in a simplified manner, and that was in 1943. Gratitude in submitting a proposal of the principle of learning algorithms in neural networks goes back to Hebb in1949, this learning process is inspired by the basic way in which the human brain learns. He indicates to the fact that neural connections are reinforced each time they are utilized, he said that if two connections were fired at the same time, it would improve the construction between them (Hebb, 1949).

Nathanial Rochester from the IBM research laboratories were the first to do simulations of a hypothetical neural network and that was the period in which the computer evolved in terms of performance and speed. However, the experiment was unsuccessful, prompting Widrow and Hoff to develop the model in 1959 was called Adaline for adaptive linear neural networks and Madaline for many adaptive linear neural networks, nowadays Adaline and Madaline are still used and proposed in different applications (Mehrotra, Mohan, & Ranka, 2001).

In 1972, Kohonen and Anderson improved a similar network; essentially it has been relied upon matrix mathematics to describe the ideas of this work. The developments in this area have continued where the idea of single layer neural networks was put up, while the first multilayered network was developed in 1975.However, it can be said that the end of the beginning of 90's of the last century is the most important event in the artificial networks field where the algorithm that trains the multilayer Artificial Neural Networks is invented. Therefore, ANNs are being used in a wide range of areas. In addition, the development of the computer and its applications led to the diversity of the structures of the networks.

4.3 Artificial Neural Network

Artificial neural network is a complicated structure inspired from the brain of human and the nervous system. In order to bring the idea closer, the general idea of the components and the working principle of human neural networks will be explained. ANN is one of the current progress and powerful tools which implements its power to answer issues that are difficult to be answered using and of the classical mathematical or programmatically used methods.

The neural network architecture and main types of ANN will be discussed in this chapter of the work

4.4 Biological neural networks

The brain is composed of thousands of millions of biological neurons connected between each other with billions of interconnections, the biological neuron is considered to be an essential unit of processing information, **Figure 4.1** shows a typical neuron consists of four parts: body, nucleus, dendrites, synapse, and axons. Dendrites are connected to the body of the cell.

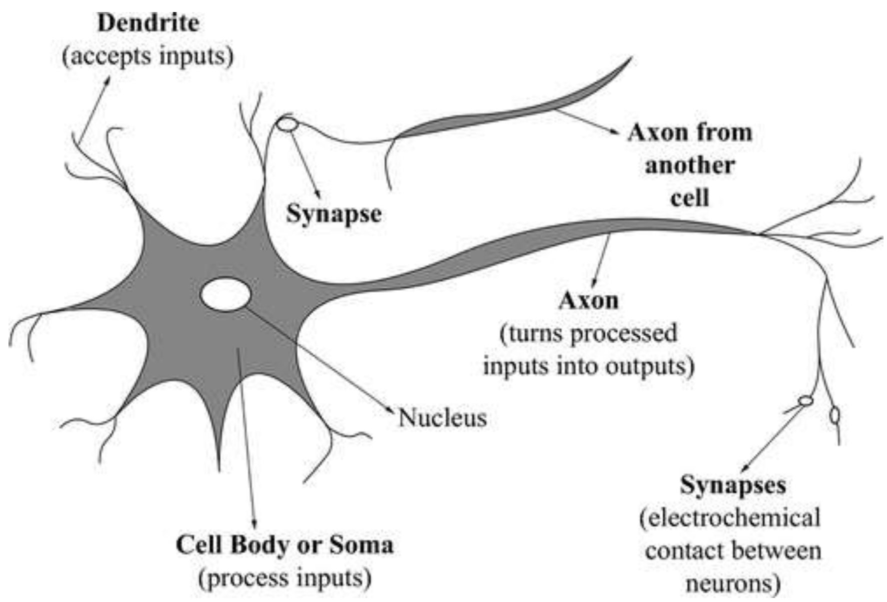


Figure 4.1: Biological neuron model

The dendrites in neuron are responsible for receiving the information from other neurons it is connected to, while the soma or cell body processes the information which received from dendrites. In order to send this information, neurons need an axon which is act like a cable, while the part which is responsible for insure the connection between the axon and other neuron dendrites are synapses.

4.4.1 Artificial neural networks structure

Artificial neural network is the simulations of the human brain in terms of information processing and learning. In order to perform its tasks, its structure depends on three basic elements: the layers, weights, and activation functions which is illustrated in **Figure 4.2**.

4.4.1.1 Layers

The artificial networks are built up using connecting weights between functional parts that are called layers. Basically, in artificial neural networks the layers are divided into three main types based on the position and function. These three types are illustrated in Figure 4.3.

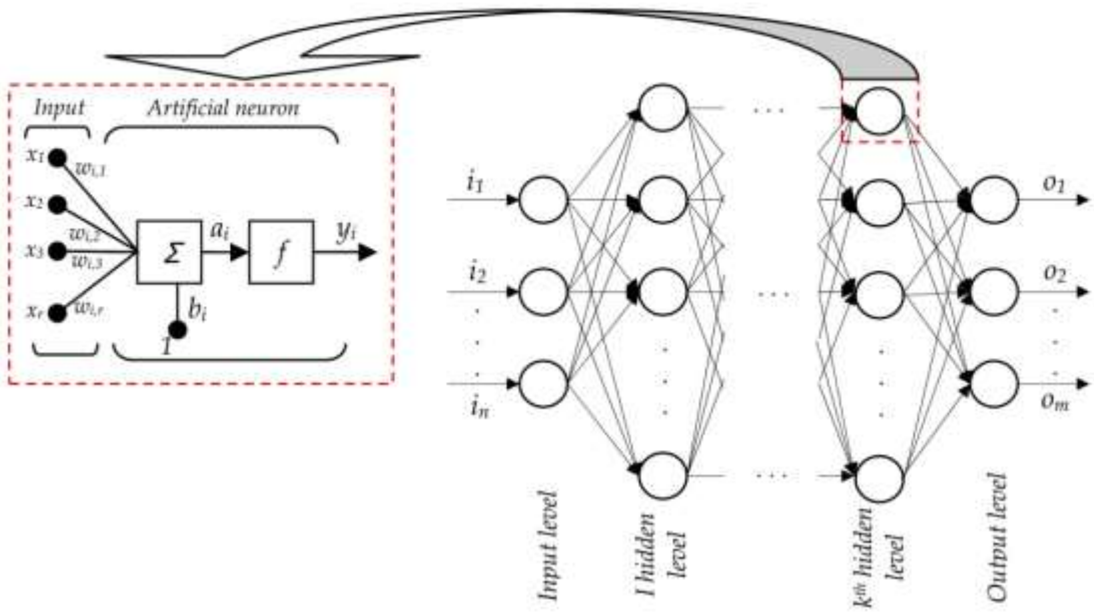


Figure 4.2: Artificial neuron and the structure of the feed forward Artificial neural network

- **Input layers:** These layers are connected directly with the inputs; the main task of this layer is to submit the input signals to the next layer, without any signal processing.

- **Hidden layers:** The basic processes are carried out in this part of networks, where the weights are being updated continuously, so the hidden layers are considered the core of the neural network structure, where it ensure the connection between the input layers and the output layer. . Next equation illustrates the output of hidden layer the input to the hidden layers which is given by the multiplication of input layer's output with the hidden weights.

$$I_h = \sum_n \omega_{hn} o_{in} \tag{3.2}$$

While the output of each hidden layer is given by:

$$O_h = f\,(-I_h) \tag{3.3}$$

Where I_h is the input of the hidden layer, $\omega_{hn}$is the hidden weight matrix, $O_{in}$is the output of the first layer, O_h is the output of hidden layer, and f is a transfer function that has different types and properties.

- **Output layer:** This layer is responsible for passing the output signals for the hidden layers to the final network output, and this is done after the signal is processed according to the following equation which illustrate the input of output layer

$$I_o = \sum_i \omega_{oi} o_{hi} \tag{3.4}$$

Where ω_{oi} is the weight matrix and $O_{hi}$is the output vector of the last hidden layer.

4.4.1.2 Weights

Weights are considered the most important factors in the artificial neural network structure, where they are defined as the numerical parameters which determine the strength or amplitude of a connection between two nodes, in other words, it can be said that weights represent the amount of influence the firing of one neuron has on another. In neuroscience and computer science each input is associated with its own weight, which expresses the strength of the effect of this input on the result in the output. These weights are adjusted according to the number of methods that depend mainly on the network structure and the learning algorithm applied. However, mathematically if the inputs are x1,x2,……x_n and the associated weights are w1,w2,….w_n then a weight is multiplied to the input to add up to form the output y as shown in the following equation

$$y = f(x) = \sum x_i \omega_i \tag{3.5}$$

4.4.1.3 Transfer functions

In biologically inspired neural networks the transfer function which is also called the transfer function can be defined as the most important factor in artificial neural network that calculates the ‘weighted sum’ and adds direction and decides whether to ‘fire’ a particular neuron or not.in other words, activation function has the ability to decide Whether the information that the neuron is receiving is relevant for the given information or should it be ignored. **Figure 4.3** shows the transfer function of one neuron in artificial networks.

There are plenty of types of activation functions, and we will mention to the common-used types.

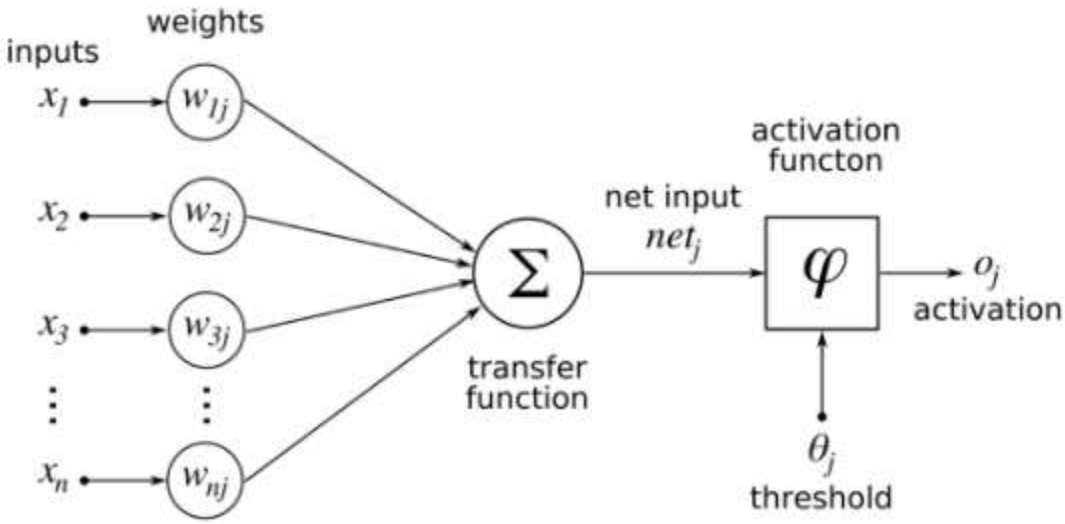


Figure 4.3: Simple structure of the neural network

4.4.2 Threshold activation function

In this type of activation role, the result is a certain value, if the total input is lower than the preset threshold value then the output is 0(not activated), and if the total input sum is more than preset threshold, the output of activation function will be 1(activated). However, this type of activation functions which is shown in Figure 4.4 could be used in binary classification schemes where the input pattern could be classified into one or two groups. The function of the hard function is defined by the following equations:

$$O(TP) = \begin{cases} 0 & if \;\; TP < \theta \\ 1 & if \;\; TP > \theta \end{cases} \tag{3.6}$$

Where TP is known as the total potential of the neuron, and Ɵ is the threshold value.

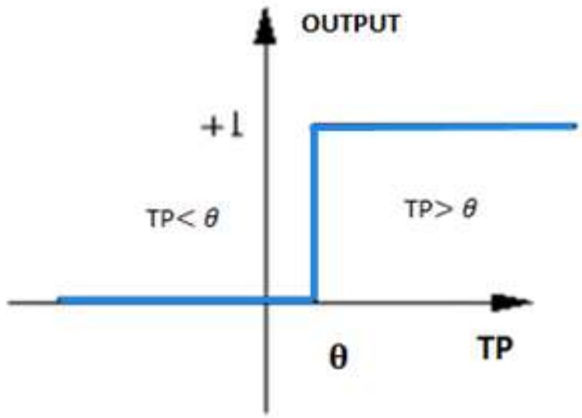


Figure 4.4: Threshold activation function

4.4.2.1 Linear or identity activation function

The term linear function is refers to the function that changes linearly with input and has no limits, where the ramp equation is used in order to generate the output which is shown in Figure 4.5, the output of the functions will not be confined between any range. This type is rarely used in neural networks where it is not considered useful in complex networks, the following equation express the linear function:

$$f(x) = x \tag{3.7}$$

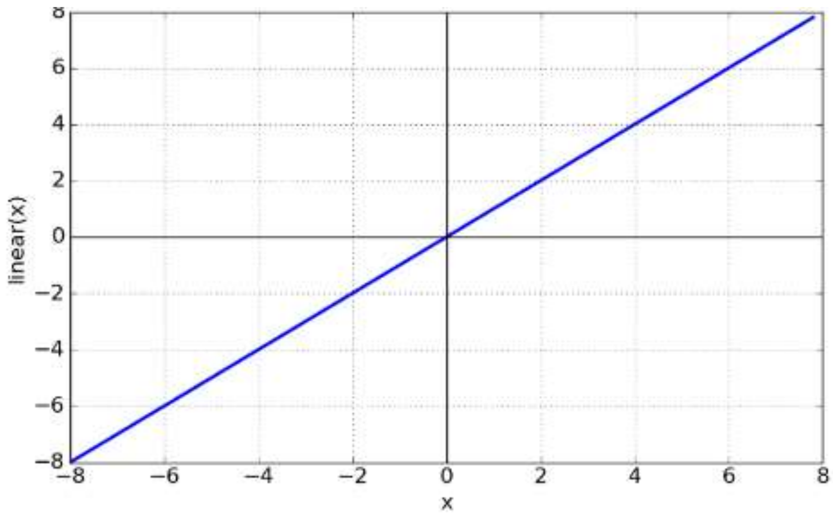


Figure 4.5: Linear or identity activation Function

4.4.2.2 Sigmoid activation function

In neural networks the activation functions can be classified into two main 2 types, linear type of activation rule and nonlinear type of activation rules. Sigmoid activation function is considered as non-linear function where it takes real infinite numbers and squeezes it to the period 0 to 1. Since possibility of value to exist between the period of zero and one is used, this type of transfer function is a good choice where we need to expect the chance of an output to appear. Mathematically it is represented as

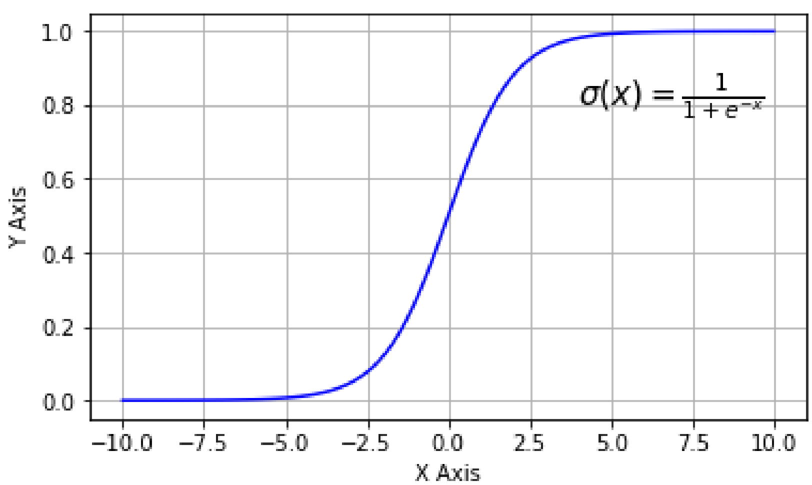


Figure 4.6: Sigmoid activation function

The Figure 4.6 illustrates the curve of the sigmoid activation function where it represents mathematically as:

$$\frac{1}{1+e^{x}} \tag{3.8}$$

4.4.3 Tanh or hyperbolic tangent activation function

This type is very analogous to the sigmoid activation role, but the output in Tanh function is ranges between two values 1 and -1, therefore, it is mainly used in the sorting of two classes or things, the output cure in **Figure 4.7** shows how the negative inputs will be drawn sturdily negative and the zero participations will be drawn around zero .Mathematically, Tnhn function is given as:

$$f\,(x) = \frac{2}{1+e^{-2x}} - 1 \tag{3.9}$$

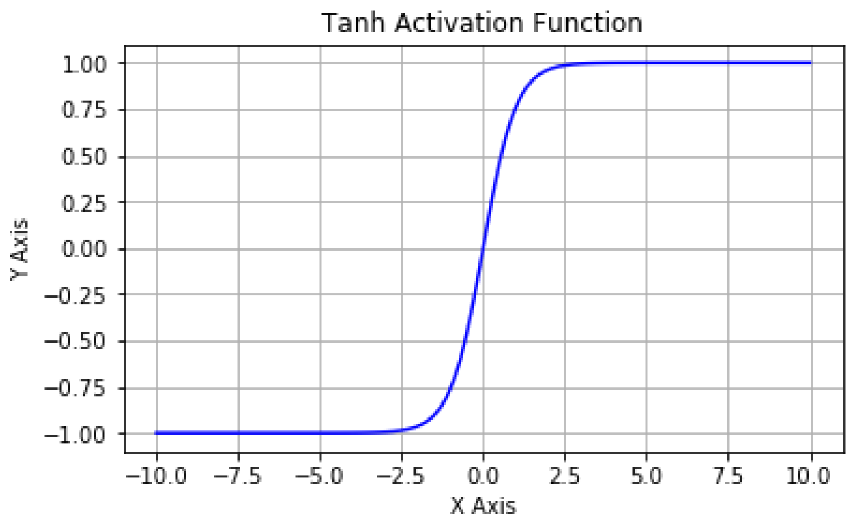


Figure 4.7: Tangent activation function

4.4.4 Rectified linear unit (ReLU) activation function

Rectified Linear Unit (RLU) activation function is a non-linear activation function which is has the ability to address a lot of problems experienced by previous methods ,therefore, RLU activation functions is most widely used these days and it is used in almost all the convolutional neural networks or deep learning. The figure 4.8 shows the output curve of Relu activation function and it is clear that the range is between 0 and ∞ where f(x) is o when x is negative and f(x) is equal to x when x is equal or greater than 0.

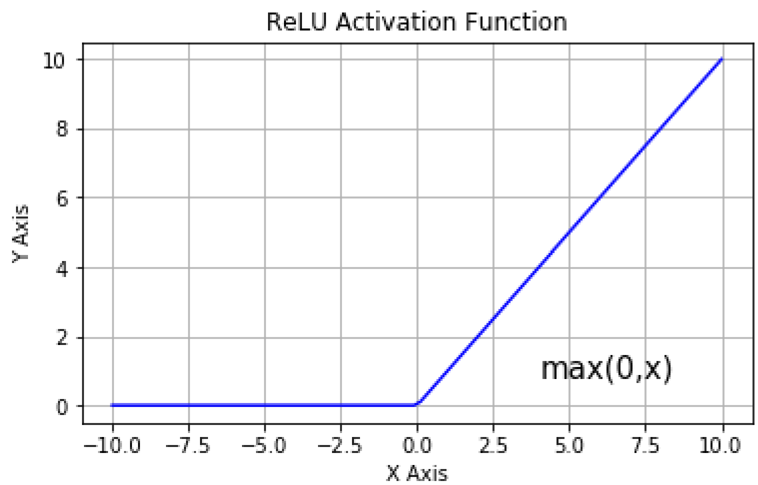


Figure 4.8: Rectified Linear Unit (ReLU) activation function

Rectified Linear Unit (RLU) activation function could be defined mathematically by:

$$f(x) = \begin{cases} 0 & x < 0 \\ x & x \geq 0 \end{cases} \quad (3.10)$$

4.5 Neural Network Topology

In neuroscience and computer science the term network topology refers to the arrangement of a network along with its nodes and connecting lines. In general, networks can be classified into two basic forms: feed-forward network and feed-back network which will be explained in detail in the next sections.

4.5.1 Feed-forward network

This network topology is considered as a non-recurrent network, which is mean that the signal flow only forward in one direction .in this type the neurons which represent the processing units in networks are connected with the processing units of the previous layers. Feed-forward Network could be divided into the following two types:

- **Single layer feed-forward network**: This structure consists only of the input layer and the output layer where there are no hidden layers and therefore is considered a simple example of feed-forward network.
- **Multilayer feed-forward network:** It is clear that the naming of this structure refers to the existence of more than one hidden layer between the input and output layer, and Figure 4.9 shows the difference between the single layer feed-forward and multiple feed-forward network structures.

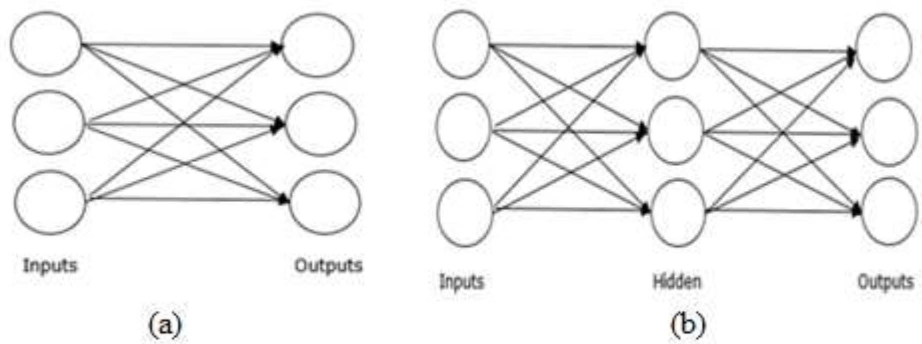


Figure 4.9: Feed-forward network topology, (a) single layer feed-forward network (b) multilayer feed-forward network.

4.5.2 Feedback network

While the previous structure- feed-forword networks- relied on one-way signal flow, the feedback networks are characterized by loops or so-called feed-back paths that allow signals to flow in two directions, feedback networks are dynamic; their 'state' is changing continuously until they reach an equilibrium point, that is why it can be said that this topology type of networks is very complicated and powerful.

4.5.3 Overall Structure of the Artificial Neural Network

The final structure of the neural network is composed of a system containing the functions defined in this chapter. The structure is composed of input layers that receive the inputs of the neural network and submit it to the first hidden layer through unified weights. The first hidden layer is the first processing layer that process the inputs and transfers the results to the next hidden layer. The process continues through hidden layers until the last hidden layer is reached. The last hidden layer then submits the results to the output layer which applies the activation function and generates the final result. The generated results are then submitted to the learning processor to decide the next action that will be applied to the weights and biases such that the network will learn the overall pattern of the input output pairs. Figure 4.12 explains this structure along with back propagation algorithm that is used in our thesis.

4.6 Learning in Artificial Neural Networks

Artificial neural network is a complex adaptive system inspired by the human nervous system, where it simulates the principle work of the human brain and therefore it can be said that the most important feature that characterize the networks and give them the greatest importance and make it an effective tool in many different applications is the characteristic of learning.

Artificial Neural networks consist of many elements which are characterized as adaptive, that is mean a processing unit is capable of changing its input/output behaviour due to the change in environment, and this behaviour is called learning. Learning methods can be divided into two main learning methods: supervised learning and unsupervised learning which will be explained in the following section.

4.6.1 Supervised learning

This method of learning is similar to the learning methods in schools, where students are first taught and then subjected to many tests to ensure that they have learned the required information. Similarly, artificial neural networks are learned by providing them with patterns consisting of the input and it desired output.

During learning process, the actual output is compared with the desired output each time in order to modify and adjust the weights the process is repeated continuously until the error between the actual output and desired output is small enough. Figure 4.10 illustrate the process diagram in supervised learning.

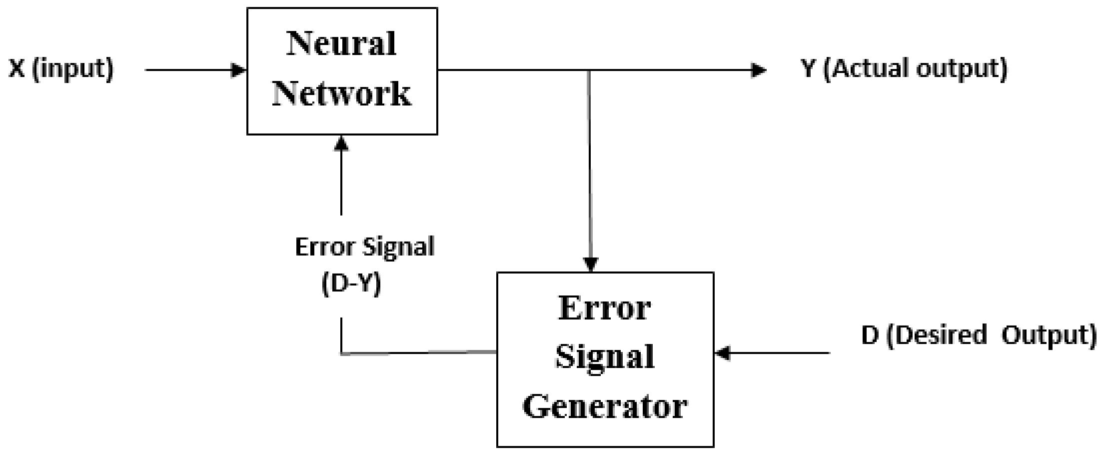


Figure 4.10: Supervised learning model

4.6.2 Unsupervised learning

This method depends on the defined conditions in adjusting their weights , in unsupervised learning the input data is provided to the networks, and depending on the structure of the input, the network is can learn itself as it shown in the 4.11 bellow.

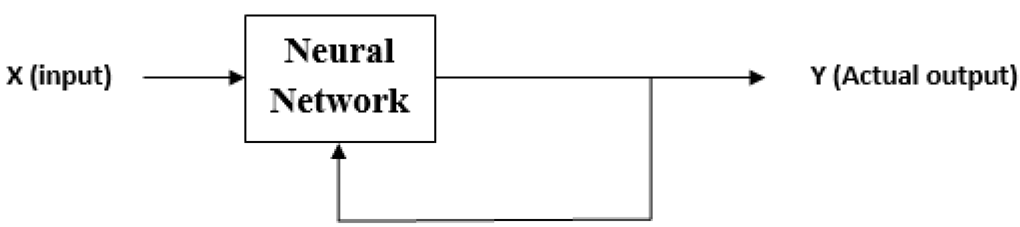


Figure 4.11: Unsupervised learning model

4.7 Back Propagation Algorithm

Back Propagation Algorithm is a good example of supervised learning method in artificial neural network which is introduced in the 1970s, this algorithm wasn't fully appreciated until a famous 1986 paper by David Rumelhart, Geoffrey Hinton, and Ronald Williams. This algorithm is a learning method that relies on a feed forward process, and a back propagation updating method. The following sections explain the model and the work principle of BP algorithm in detail.

4.7.1 Model of back propagation algorithm

Back propagation algorithm is a learning method which uses the back propagation process in the process of adjusting and modifying the weights in layers in order to train the network, where the pair of the inputs and its correspondent desired output is used. **Figure 4.12** bellow illustrates the general structure of back propagation algorithm.

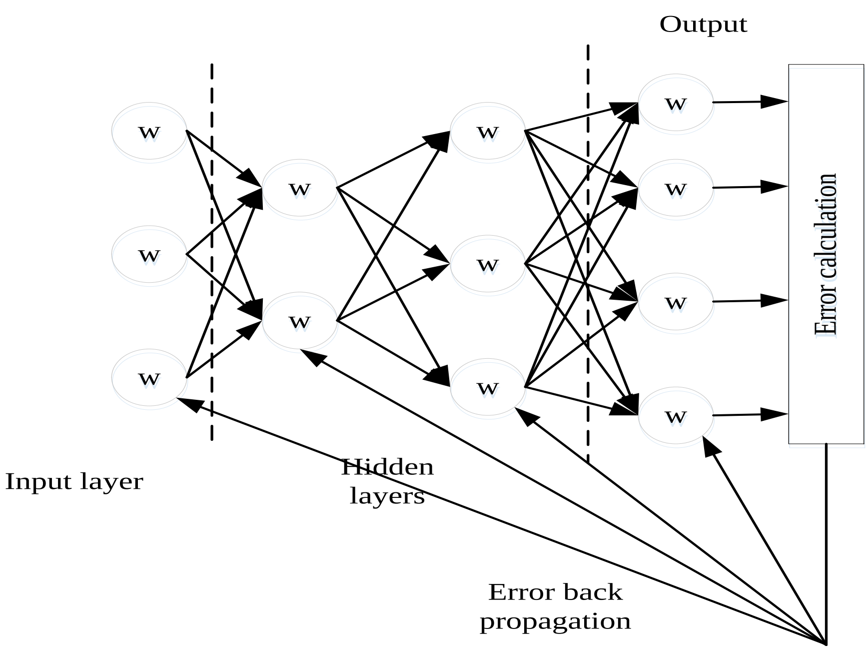


Figure 4.12: Model of back propagation

The first step is to calculate the actual output of the inputs by passing the inputs in forward iteration, then the error is calculated which expresses the difference between the desired output and the actual output and is propagated back to the first hidden layers of network, During this phase the weights are adjusted according to certain rules to ensure that the error is converged to zero or to the smallest possible value. In order to implement this algorithm on the networks, it is necessary to identify many parameters that affect the performance of the network such as: learning rate, momentum rate, mean square error MSE, and maximum epoch.

Learning rate it is used to control how fast the network learns the training examples, in other word, this parameter determines the step size for updating the weights in training phase. While, Momentum rate is helpful parameter which takes a value ranges between 0 and 1, this parameter has the ability to reduce the possibility of the network in getting trapped in a poor local minimum during training. The other parameter that has an important role in the training phase of the network is Goal of cost function (MSE).Generally, when the network reaches to specified value, then the training phase should be stop, since a cost function follows that there should be a specified value for the goal of the cost function being minimized. In back propagation neural network the structure of layers depend on many factor but it must be at least three layers include input layer, output layer and hidden layer where the error is propagated back iteratively until the minimum error value is obtained in the output. The following equation represents the value of the error in the output:

$$E = \sum (T - Y)^2 \tag{3.11}$$

Where T is the target output and y is the actual output in neural network. A propagation error is then given by:

$$e_j = (T - Y) * Y^{\backslash} \tag{3.12}$$

If the output is defined using a sigmoid function, then the error function could be written as:

$$e_j = (T_j - Y_j) * Y_j * (1 - Y_j) \tag{3.13}$$

Where the derivative of the output y is:

$$Y^{\backslash}(x) = Y (1 - Y) \tag{3.14}$$

4.8 Applications of Artificial Neural Network

In today's society the artificial neural network has many applications in wide range of activities in order to develop numerous fields; this technique has the accuracy and significantly fast speed than conventional methods. Moreover, neural networks can learn by example, hence we do not need to program it at much extent, however these features make this technology effective in many applications such as medical diagnosis, system identification ,electronic trading, robot control, remote sensing, finance, healthcare, education, transportation, and more.

ANN is regarded as a revolutionary technique in many areas where has been extensively applied in the field of medical diagnosis in order to help physicians perform diagnosis and other enforcement. The ability of networks to handle large amounts of data and shorten the required time by conventional methods makes this technique an effective method to increase the patient satisfaction and reliability.

One of the most important areas for ANNs applications is security systems and identity authentication, however, the recognition systems depend on the biological characteristics of the person such as the iris, face, fingerprint, teeth, ear or depending on the behavioural characteristics of the person such as voice and walking style. In any case, these systems are widely used in security systems, for example, in bank or smart homes, in order to identify the presence of a stranger at home .Moreover identity authentication and recognition systems by using artificial neural networks are used in state security institutions, social institutions and service institutions.

Since ANN is characterized by high efficiency and the ability to simulate the human mind, the applications were not limited to only the previous areas; today the artificial neural network is widely used in many applications such as financial expectation of the companies and weather forecast because of their ability to learn and training.

CHAPTER 5

IRIS RECOGNITION SYSTEM AND RESULTS

5.1 Introduction

In this chapter, results of the application of artificial neural network for the detection and person identification based on the iris images is going to be presented and discussed. As said previously, the database of 50 person iris images were collected and arranged to be used in our program. This database was processed using different processing methods to ensure the ability of the applied neural network to estimate the pattern in the images and classify them. The results of this chapter can be, later on, generalised and applied for larger database sets to be more useful in real life applications. Iris recognition can be very useful in simple applications like employees presence detection systems or in more complicated and sensitive applications like access identities for hospitals, banks, or properties. It also can be very useful in mobile access applications for the ease of mobile access. As a biometric sign, the iris is well known for its uniqueness and special features that make it one of the most famous biometric signs.

In this chapter, all practical works and results will be presented and discussed with images. At the end of the chapter, general conclusion will be resuming the results of this work and presenting the plan for future works.

5.2 Database and database collection

The database images of 50 person was collected from the UTIRIS bank (Hosseini, Araabi, & Soltanian-Zadeh, 2010). UTIRIS is a hybrid database that has two different sets of IRIS biometric images in visible waves and near infrared light. The images were collected from the right and left eyes of the individuals. The database is presented in well organised files under JPG imaging format which makes it easy to process and work on it.

(a)Left iris image (b) Right iris image

Figure 5.1: Database images of IRIS

5.3 Adding noise to iris images

The proposed system is supposed to work in real life conditions in which the eye images are possible to be captured in different modes. Some dust or water drops can make the iris image noisy and difficult to be recognized. Any recognition system should be trained for all possible cases and has the ability to overcome the noise problems. The data base images were treated in three different manners to ensure the system is able to identify person even in the presence of the noise. Two types of noises were added to some of the database images like it can be seen in Figures 5.2 and 5.3. Speckle noise was added to some images while Gaussian noise was added to other images. The rest of images were kept noiseless such as the one shown in Figure 5.1.

(a)Left iris noisy image (b) Right iris noisy image

Figure 5.2: Iris images after speckle noise addition

The addition of noise was ensured using MATLAB functions so that it could be easy and well established. The noisy images are fuzzy and can be more difficult to be recognized unless the system is well trained for such types of images. Other types of noise could also be used in our program but for simplicity we have chosen to use two types of noise.

(a)Left iris noisy image

(b) Right iris noisy image

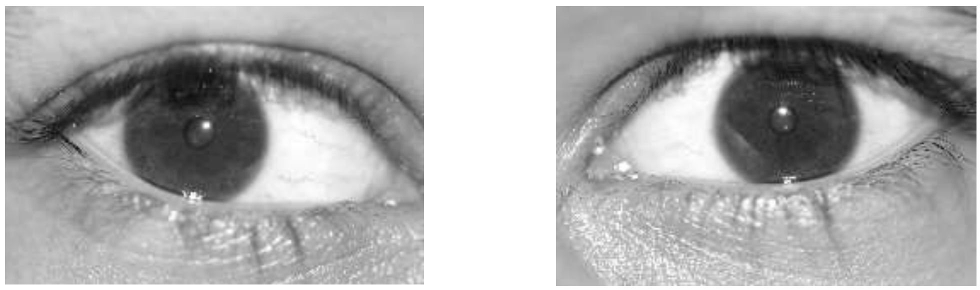
Figure 5.3: Iris images after Gaussian noise addition

5.4 RGB to gray image conversion

RGB images are composed of three colour concentration values for each pixel. They contain more data about the image that can be understood and translated by human visual system. The human brain has the ability to translate images into classified things and colours. However, the computers are less interested in colour images as they don't have the human senses. The computer is mainly concerned by details and features in the image rather than colours. The processing of coloured images is also costly and needs more processing power and time to be done effectively. Any coloured image is composed of mix of the three basic colours of nature which are Red, Green, and Blue. All colours are mixtures of different concentration levels of each one of these colours. In our work, all coloured images are going to be converted to gray scale images. Gray scale images have smaller size than RGB images and thus reduce the processing cost in any computer system. The conversion from RGB image to gray image is done by applying the next formula that takes in consideration the sensitivity of the human eye to each one of the basic colours (Zollitch, 2016).

$$\text{Grey pixel} = 0.299 * R + 0.587 * G + 0.114 * B \qquad (3.1)$$

The above mentioned formula makes the image totally independent of the colours but similar to what the human eye sees. The terms R, G, and B refers to the concentration of Red, Green, and Blue colours respectively. The next figure shows the left and right iris images after being converted to gray scale from RGB images. The images, as it is clear from the figure, contain all the features of the original image except from the colour. The human brain has high ability to identify these images with no great efforts in both gray scale and coloured versions. For computer, the process is more complex and can take more time and effort in the case of coloured image.



(a)Left iris gray scale image (b) Right iris gray scale image

Figure 5.4: Gray scale version of iris images

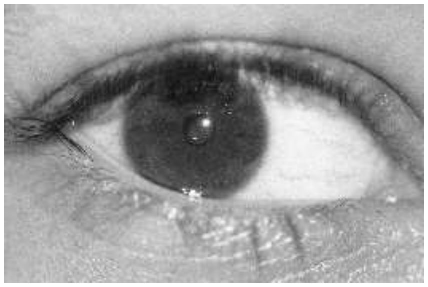
5.5 Treatment of image noise

As discussed earlier, in order to test the capability of our program; the IRIS images were all treated with different levels of noise. These noises were added to the images using MATLAB built in functions. Two types of noises were added as shown previously in this chapter. The treatment of the noise was carried out using Wiener adaptive filter and Median filter. After applying these two filters on the noisy images, the results of the filtering process are shown in the next two figures.

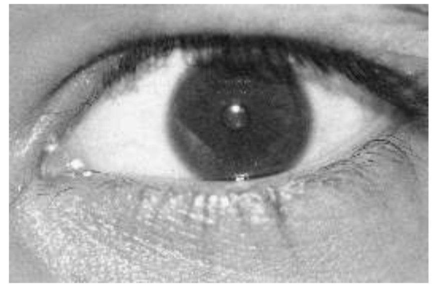
(a)Left iris Median filter image (b) Right iris Median filter image

Figure 5.5: Median filter applied to noisy iris images

Figure 5.5 presents the image of right and left iris images after applying Median filter with 3x3 windows. It is seen that the noise have been almost removed from noisy images. Figure 5.6 presents the application of Wiener filter to noisy images.



(a)Left iris wiener filter image



(b) Right iris wiener filter image

Figure 5.6: Wiener filter applied to noisy iris images

5.6 Resizing the IRIS images

After filtering the iris images of database, it is important to keep in mind that the size of these images is very large. The original RGB image size is 1360*2080*3 which is equal to 8486400 pixel values. The gray scale image of the same size is 1360*2080*1 or 2828800 pixel values. This number of pixels is very huge to be processed with all iteration for each one of the IRIS images. Such a huge number will need huge memory to handle and huge processing capabilities to be able to process. The reduction of the image size without losing main features is the first and cleverest idea at this point. Size reduction can be carried out by averaging the pixel values using a moving window of square area. Or it can be carried out using the bi-cubic interpolation method applied in MATLAB. This latter was chosen to be used in our work to resize the iris images to 30*30 images.

5.7 Preparing ANN inputs

At the end of the image processing, the resulting images are to be arranged in special form to be fed to the neural network. All database images are converted to one dimension vectors. These vectors are all being fed one by one to the network successively during the training and test processes along with the target values of each image. The neural network is supposed to create input-output relationships between the images and their targets during the training process. The repetition of the training process over the time is responsible for the adjustment of the neural weights in the correct direction of error minimization. When the error is small enough, the network is then ready to be used for test or recognition process. The test is similar to the training in all parts except from the absence of the weight adjustment part. The generated outputs are used as final judgments of the network.

5.7.1 Structure of the network

In this part, simple neural network was built of 2 hidden, 1 input, and 1 output layer. 8 images of each one of the 50 person's Iris were used in our program. 5 Iris images were used for the training and 3 images were used for the test of ANN. The neural network parameters are presented in the Table 5.1 below:

Table 5.1: Parameters of the first neural setup

Parameter	Value	Parameter	Value
Hidden Layers	2	Learning rate	0.01
hidden layer sizes	500, 400	Momentum factor	5%
Output layer size	10	MSE	0.001
Hidden layer functions	"Tansig", "logsig"	Training time	27m20s
Output layer function	"tansig"	Test time	0.01s
Training performance	99.6%	Test performance	82%
Number of iterations	6999	Obtained error	0.042

The table above shows that the network took 27 minutes and 20 seconds to reach the MSE of 0.042. The training took 6999 epochs. Hidden layer sizes and types were chosen based on more than 20 different trials with different layer functions and sizes until a best performance criteria was met. The performance of the trained network reached 99.6% while the test has reached the performance of 82%. Figure 4.7 below shows the curve of mean square error during the training. In figure 4.8, the structure of the implemented neural network is presented.

It is consist as the structure shows of two hidden layers and one output layer. The hidden layers are of tangential and logarithmic types respectively. The output layer is tangential because it show better performance compared to other types of transfer functions in our work.

Figure 5.9 shows the training stage of the artificial neural network. Figure 5.10 shows the fitting curve of the neural network at the end of the training process.

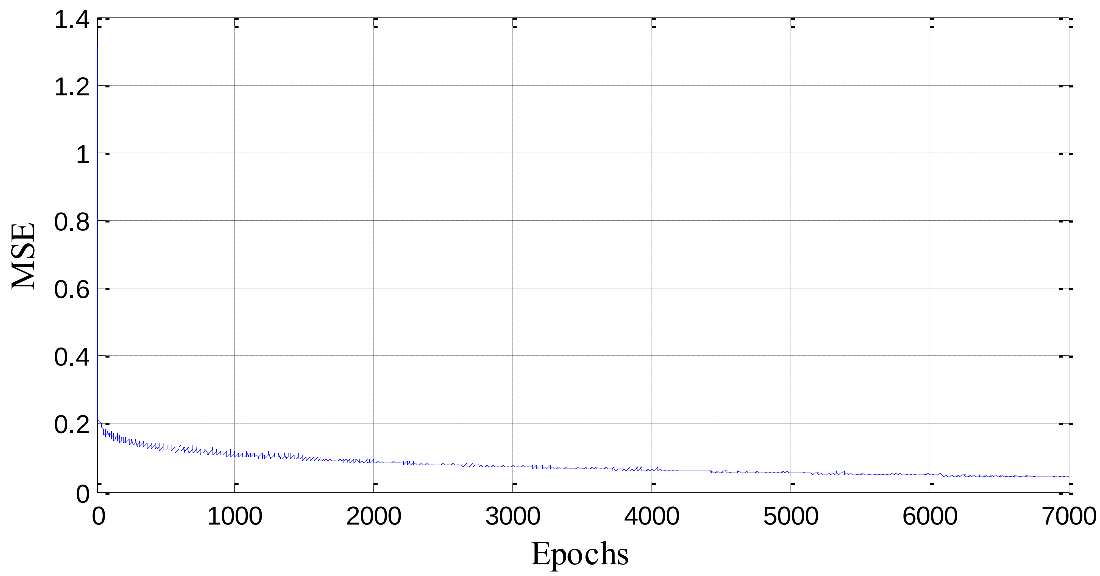


Figure 5.7: Curve of the training MSE

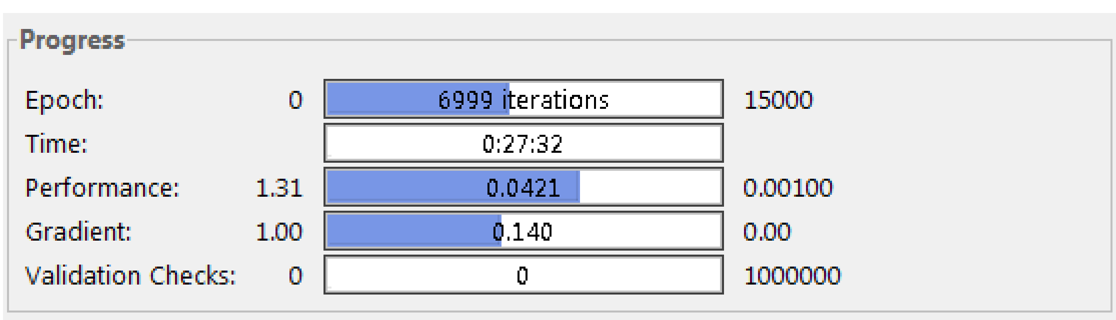


Figure 5.8: ANN training tool during the training of the network

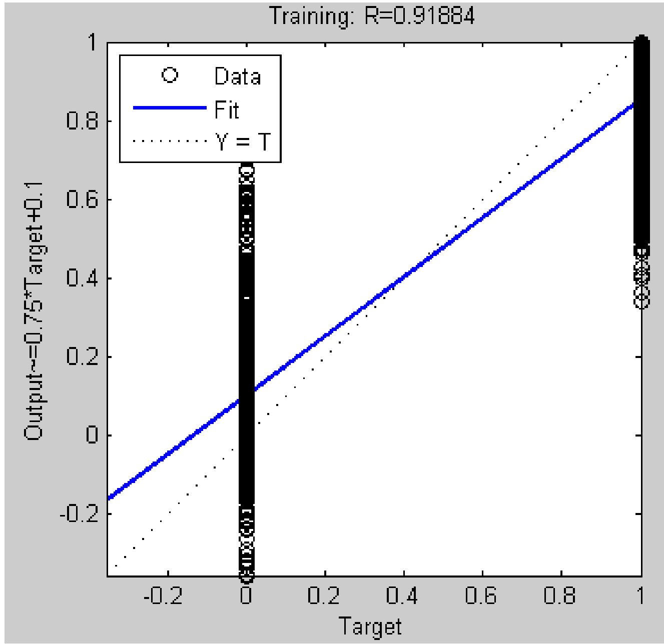


Figure 5.9: Fitting of the training output

5.8 Effect of Parameters on the Performance of the Neural Network

The neural network structures are based on the brain like learning algorithms. These algorithms are all based on mathematical models. The parameters of the models are very important in deciding its behavior. We will study the effect of changing the parameters of the neural network on the behavior and performance of the network. The main parameters that we are going to change are: the learning rate, the momentum factor, the hidden layer's sizes, and the values of the bias vectors.

The structure of the network was built and all the images were processed similarly. The training of the neural network was initiated with different parameters. The results of the training of neural network are presented in the next table. **Table 5.2** below shows the parameters of the neural network and the respective training and test results. The different parameters have changed the obtained results from the training and test. Best training performance was obtained in the fourth experiment and reached 96.4% while the test performance reached 98%

.

Table 5.2: Results of neural network with different parameters

No	Learning rate	Momentum factor	Training time (s)	Bias values	Training performance	Test performance
1	0.01	0.005	362	< 0.01	94.8%	86%
2	0.01	0.1	260	< 0.01	95.6%	86%
3	0.001	0.1	221	< 0.01	94.8%	98%
4	0.001	0.1	301	< 0.10	96.4%	98%
5	0.001	0.1	267	< 0.5	96%	56%
6	0.001	0.2	180	< 0.2	97%	96%

From the above table it was found that limiting the bias value was important in improving the results of training of the network. **Figure 5.** below shows the general shape of the MSE curve in function of time during the training process. The curve shows how the MSE decreases with the training. The MSE is a best measure of the convergence of the network toward the developed targets.

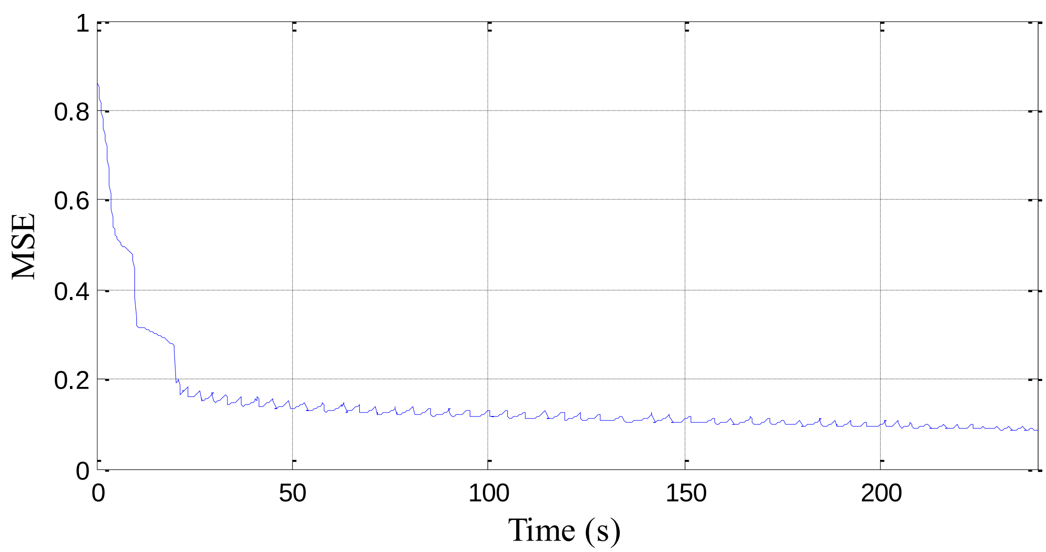


Figure 5.10: Curve of the mean squared error

5.9 Comparison of Different filter Types

In this part of the work, a comparison will be carried out between 4 different cases using the parameters given in the next table. Median filter, Wiener filter, Wavelets, and unfiltered images will be processed in this experiment. After applying these filters on the images, all results were obtained, tabulated, and compared.

Table 5.3: Parameters of the applied neural network

Parameter	Value	Parameter	Value
Image size	100*100 pixels	MSE goal	0.001
Input layers	10000 neurons	Train images	250
Hidden layers	[500 250 200] neurons	Test images	150
Output layer	50 neurons	Learning rate	0.001
momentum	0.01		

5.9.1 Raw images without filtering

First experiment was carried out without considering any kind of image filtering. The training of the network took around 300 iterations during 420 seconds to reach the required MSE goal as shown in Figure 5.12. Performance of 86% in the training and 82% in the test were obtained.

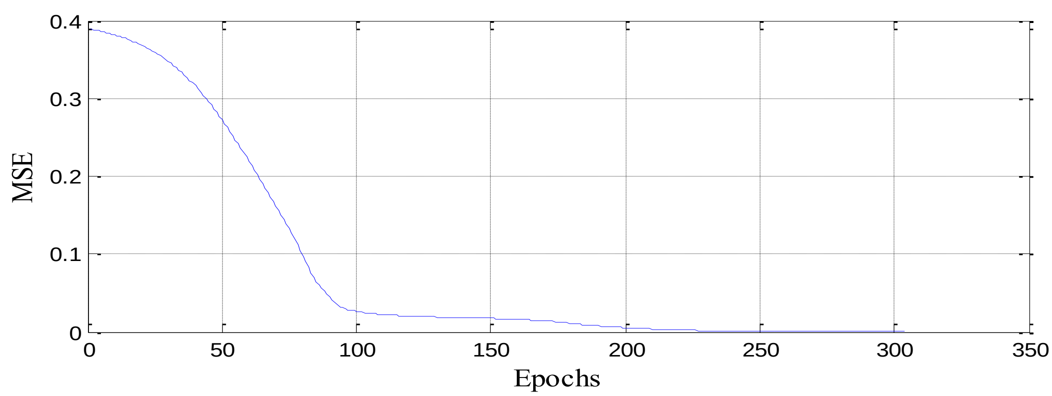


Figure 5.11: MSE training curve

The output is generated from the neural network. The outputs were taken directly from MATLAB without applying any thresholds. Threshold will be applied to these outputs in order to generate outputs limited to ones and zeros. These outputs will be then compared with the target codes to decide which image belongs to which person.

5.9.2 Wiener filter

Wiener filter was applied in this experiment during the image processing phase of the network. The training of this network finished by obtaining a good and small enough Mean Squared Error value. It took 400 seconds to obtain the required MSE value during 300 iterations. The training of the images has given a performance of 98% by correctly recognizing 245 images of 250 training images. The test of the network has given a performance of 96%. 144 images of the 150 test images were correctly recognized **Figure 5.** presents the evolution of the MSE curve of the training process.

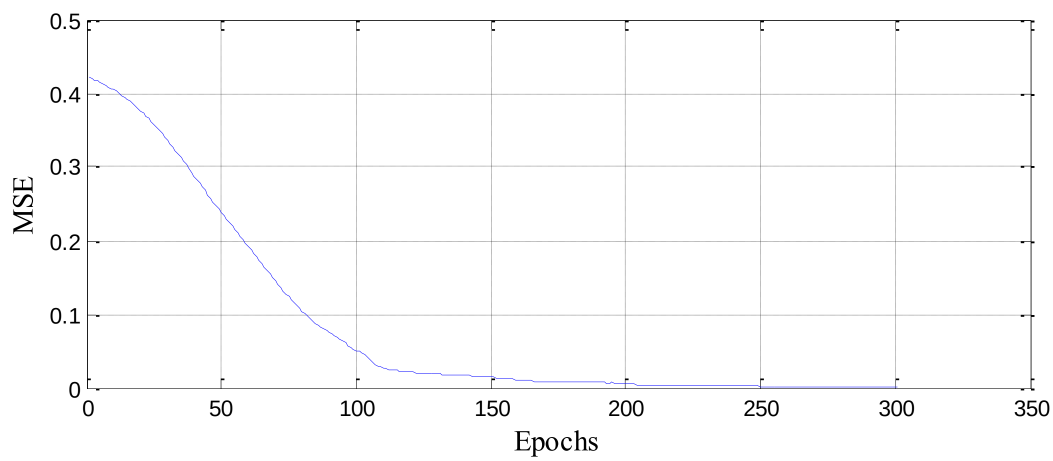


Figure 5.12: Evolution of the MSE curve during the training

The output of the neural network with wiener filter is generated. 12 different vectors of the output are presented in the table. The output is considered true when its output is more than the threshold and false when its output is less than the threshold.

5.9.3 Median filter

Median filter was also used in the filtering of Iris images before using them with the neural network. Training the images has given a training performance of 95% while the test has given a performance of 92%. The training of the network took around 260 iterations before reaching the required MSE as presented in **Figure 5.**.

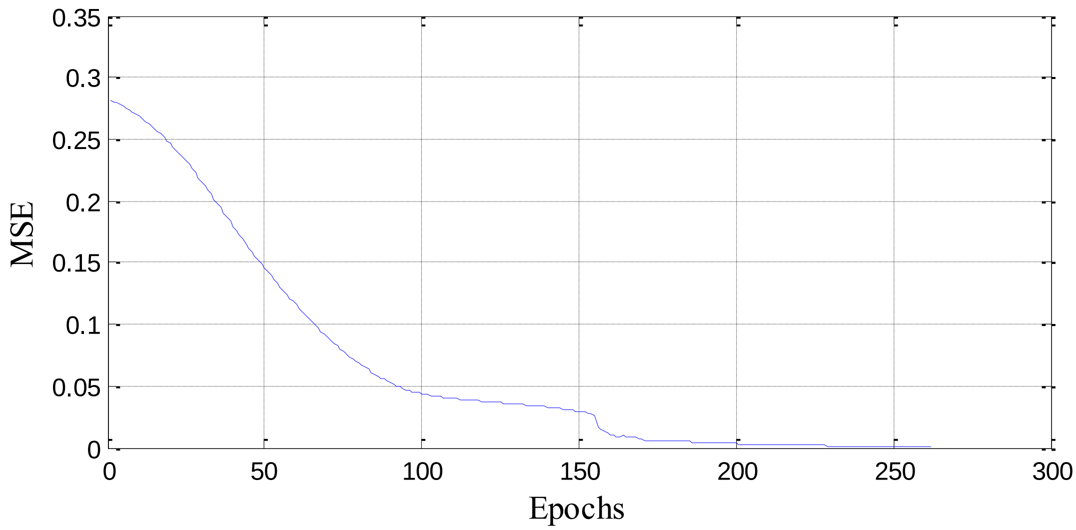


Figure 5.13: MSE curve during the training of the network

The output of the neural network is presented in the next table. The output vectors of 11 different images are presented in the table. The values represent codes of the output that were chosen arbitrarily for each person. The output is marked true for a given person if it best fits his chosen code with accepted error.

5.9.4 Wavelet transform of the IRIS image

Wavelet transform application has given a performance of 93% in the training process and 89% performance in the test process. The curve of the MSE during the training is presented in Figure 5.15 below. The performance of the network with wavelet transform was less than the other used methods.

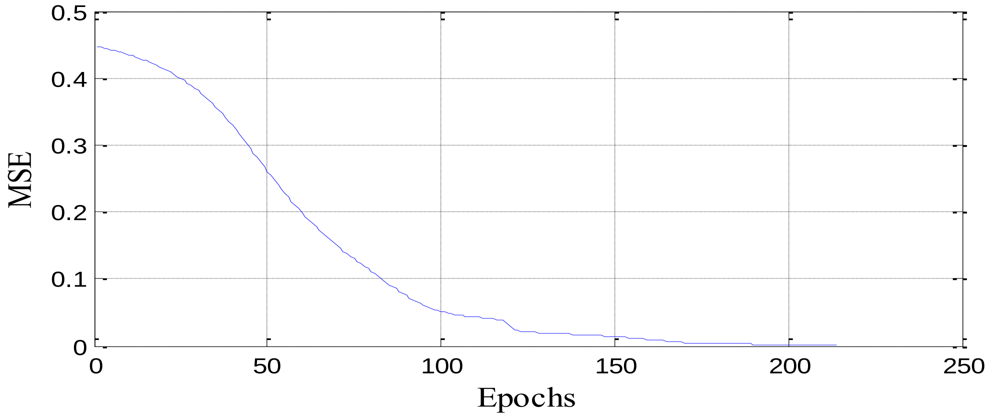


Figure 5.14: MSE curve of the training network

5.10 Comparison of Considered Methods

In this part, the different results obtained in this thesis will be tabulated for comparison. Table 5.8 below presents the summary of the obtained results of applying neural network with different image processing techniques. The table shows that Wiener filter increases the training and testing performance of ANN which is followed by Median filter. Results show that feeding original images is not sufficient for ANN. Applying different techniques may increase both training and test performance.

Table 5.4: Comparison of different results

Method	Training performance	Test performance
Wiener Filter	98%	96%
Median Filter	95%	92%
Haar Wavelets	93%	89%
Original Images	86%	82%

The obtained results were satisfactory in this stage compared to the results obtained in other researches. In (Masek, 2003), the author states he reached an accuracy of 83.93%. In

(Ma,Wang, &Tan,2002), the authors present an effective method by using multichannel Gabor filtering which leads to give an accuracy rate of 94.9%. In (Devi, 2017), the author has studied the IRIS recognition using different methods with accuracy of 70%. (Sharkas, 2016) has presented her paper on IRIS recognition using neural network structure with accuracy 98% using DWT transform. (Thumwarin, Chitanont, & Matsuura, 2012) has presented his paper studying the IRIS recognition with maximum accuracy of 94.89%. an accuracy of 96% was obtained in (Sun, Zhang, Tan, & Wang, 2014) using different processing methods of IRIS recognition. In (Dillak & Bintiri, 2016), the authors presented a method for IRIS recognition base on image segmentation, enhancement, and features extraction. They obtained an accuracy of 94% out of their proposed algorithm. 97% accuracy was also obtained in (Sundaram & Dhara, 2011) using Haralick algorithm with neural network for IRIS recognition. The results we have obtained in this work shows high accuracy among the stated works and prove better performance with respect to these works.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

Artificial neural network has become one of the major fields of science that is implemented in different aspect of modern science. Neural network is thought to be working like the human brain structure. Many scientists believe that neural networks is going to develop until it will become self-learning and it will be able to do all human brain tasks perfectly. Applications of neural network are increasing with the sunrise of every new day.

IRIS recognition is very well known since many years. IRIS is known as one of the unique biometric features in human beings. That is, IRIS is being used since years for biometric identification of persons in banks, security services, and many governmental departments of many countries. Different IRIS recognition methods were proposed and implemented in this field and offered good performance. IRIS is advantageous for person identification because it needs no effort from the person to be used. IRIS can be captured automatically using special cameras while the person is walking.

In this work, the study of IRIS recognition for biometric person identification and security applications using artificial neural networks has been presented. The application of back propagation artificial neural network was discussed and implemented in this work. Database of IRIS images form 50 person was collected and developed to suit the proposed aim. All database images were processed and treated using different image processing techniques to ensure the accuracy of the neural network in the identification of the person. Image processing helps identifying the position of IRIS. It helps also improving the quality of captured image and rejecting any type of noise that can appear on it. Image processing techniques are also used to extract the IRIS from the face image and to extract special features from these images. The implementation of neural networks is meaningless here without the existence of different image processing techniques.

After applying the proposed methods using neural networks tool in MATLAB, the obtained results have shown high performance and given good results. Simple structure of back propagation neural network that contains two hidden layers was implemented. The training process of the ANN has given a maximum performance of 98% while the test performance has given 96%. Most of the test and training images were identified correctly and given high performance.Considering the effect of applying image processing techniques applied in this work on the training and test performance, Wiener filter increases the training and test accuracy of the ANN.

This work is a first step for the work on IRIS identification system that can be continued and extended toward the implementation of real life IRIS recognition applications. Neural networks can be built based on different processing systems and implemented to do the task.

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