



**Sudan University of Science & Technology**

**College of Engineering**

**Biomedical Engineering Department**



# **Automatic Detection of Diabetic Retinopathy (DR) Image**

**الكشف التلقائي لشبكية مرضى السكري بواسطة معالجة  
الصور الرقمية**

A thesis submitted in partial fulfilment of the requirements for the  
degree of Baccalaureate of Biomedical Engineering

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## **DECLARATION**

We Thoyba , Esraa, Alaa , confirm that the work presented in this thesis is the our own .Where information has been derived from other sources , We are confirm that this has been indicated in the thesis.

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Alaa Esameldeen Hassan

## **DEDICATION**

We dedicate this thesis to:

Parents who always guide us to the light.

Brothers and Sisters whom are our soul mates.

Friends who share us our life, make it easier and more beautiful.

Teachers who taught us how to think, express and execute.

Our Supervisor who guide us throughout this thesis and gave us the opportunity to do it.

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## **ABSTRACT**

Diagnosis and treatment of the retina images which capturing by fundus camera, This images are to be processed for better diagnosis and treatment by certain features.

This project analysis of color retinal images acquired through fundus camera from patients treated for DR .

Results show the accuracy for image base classification of normalities and abnormalities due to DR which help in early detection and therapy .

## المستخلص

. معين تصوير جهاز بواسطة تؤخذ التي العين شبكية صور مع والتعامل التشخيص  
. افضل تشخيص على للحصول بمعالجتها قمنا الصور هذه  
. بالسكري تاثيرها ومدى ملونه شبكيه صور بتحليل قمنا المشروع هذا وفي  
من نسب بها طبيعيه غير وصور طبيعيه صور الى الصور وتصنف الدقه نسب تعرض النتائج  
يساعد وومما بالسكري الشبكيه لاصابة المبكر الكشف في تساعد مما السكري بمرض الاصابه  
. التشخيص في

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## 1 - Introduction

### 1.1 Eye structure

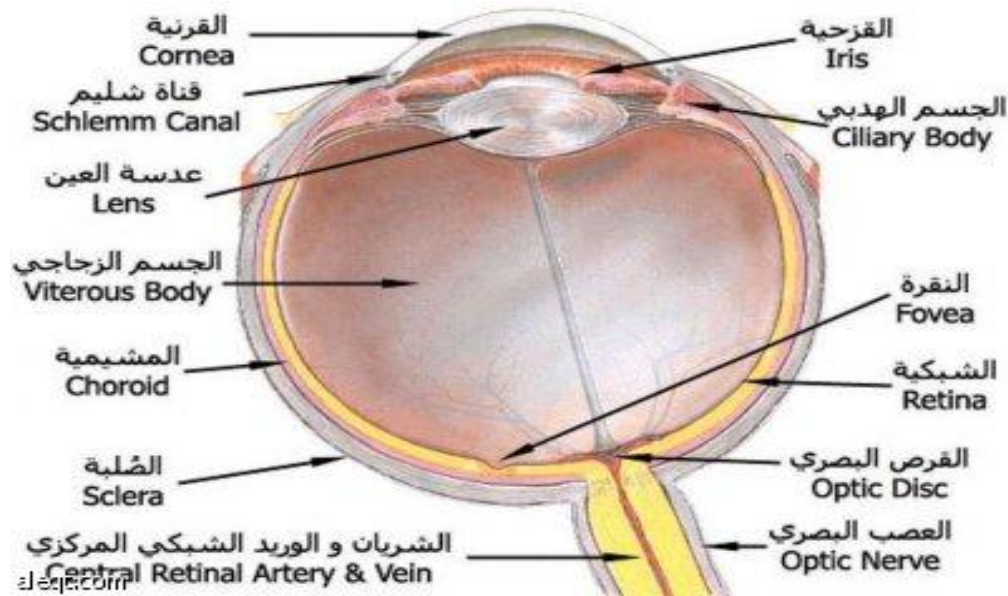


Figure 1-1

The retina is an interior surface of the human eye which acts as the film of the eye. It converts light rays into electrical signals and sends them to the brain through the Optic nerve. The optic nerve is the cable connecting the eye to the brain. The optic disc is the bright region within the retinal image, it is the spot on the retina where the optic nerve leaves and blood vessels enter the eye. The macula is a small area near the central part of the retina which is responsible for central light vision. The fovea is an indentation in the center of the macula.

This small part of the retina is responsible for highest visual acuity. The vascular network supplies oxygen, nutrients, and blood to the retina [1].

#### Blood vessels:

od vessels are usually referred to The retinal blo arteries and veins. Then artery and central vein normally appear near each other in the nasal side of the optical disc center. Blood vessels are clearer in the green component. Information about the

structure of the blood vessels can help to classify the severity of the also serve a a reference during operation .

tionAnd two strategies have been used for the detec of blood vessels in image. One is the detection of edges; and the other is monitoring that requires a priori knowledge of the position from the image .

Information about blood vessels can be severity or as part of process of automated diagnosis of diseases with ocular manifestations. Blood vessels can act as landmarks for localizing the optic nerve the fovea ,(central vision area) , and lesions . As a result of systematic or local ocular disease ave the blood vessels can h measurable abnormalities in diameter and color . foe example , central retinal artery occlusion usually causes generalized constriction of retinal arteries hypertension may ,result in focal constriction of retinal arteries , clusion typically central retinal vein oc produces dilated tortuous veins arteriosclerosis can cause the arteries to acquire a ,copper or silver color and diabetes can generate new blood ,(neovascularization) Thus ,reliable method of vessel detection is needed h preserves various asurementswhic vessel me [2] .

## 1.2 Eye diseases

There are many diseases leading causes of blindness like Glaucoma , age –related macular degeneration (AMD),cataract,and Diabetic Retinopathy( DR).

DR is a complication in the retina due to diabetics. Diabetes mellitus is a chronic , lifelong condition that affects your body’s ability to use the energy found in food . there are three major types of diabetes : type 1 diabetes , type 2 diabetes and gestational diabetes.

Normally , your body breaks down the sugar and carbohydrates you eat into special sugar called glucose ( that fuels the cells in the body ) but the cell need insulin in order to take in the the glucose and use it for energy.

In DM, either your body does not make enough insulin ,it can’t use the insulin. it does produce , or combination of both.

## Type 1 diabetes

- It called juvenile-onset diabetes .
- In people with type 1 the damaged pancreas does not make insulin .
- Medical risk are associated with type 1 : damage to the tiny blood vessels in the eyes ( diabetic retinopathy ) , nerves and kidneys .

## Type 1 Diabetes

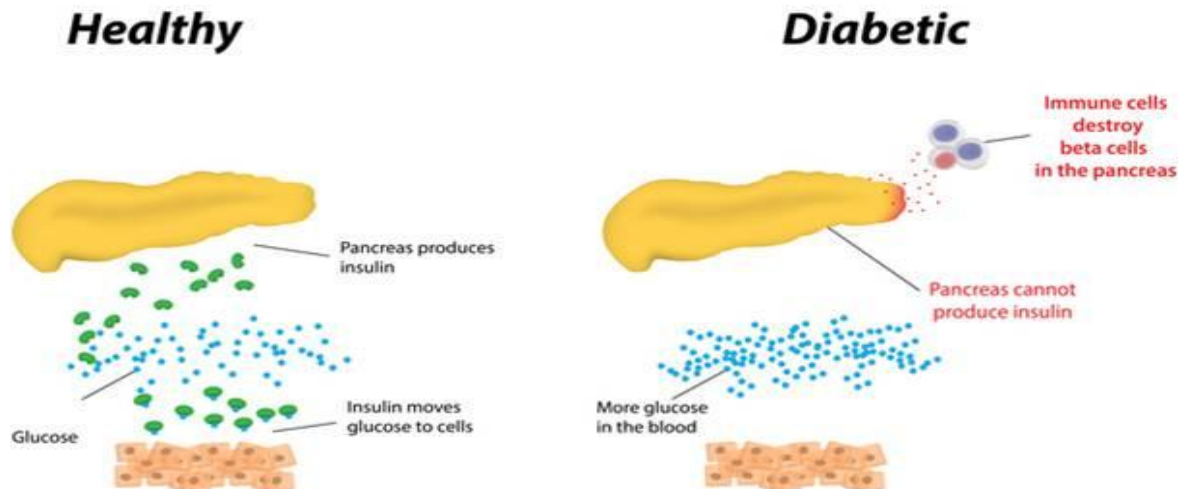


Figure 1.2

## Type 2 diabetes

- The pancreas produces some insulin but isn't enough.
- It is most common and it called adult-onset diabetes, it associated with obeses.
- It cause major health complications .

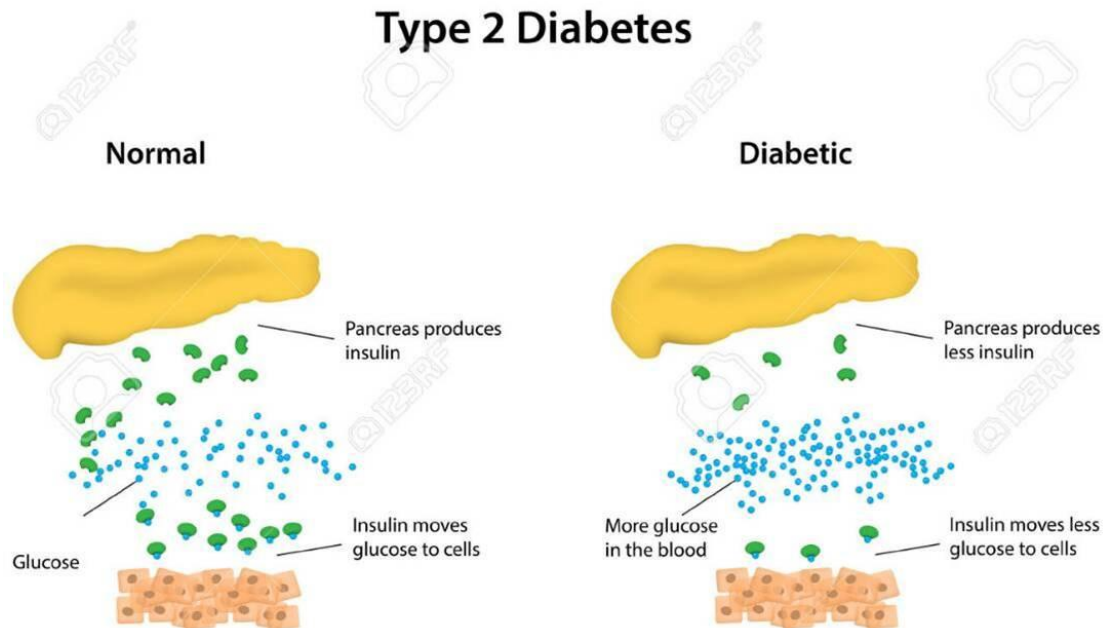


Figure 1-3

- Diabetic retinopathy is a complication of diabetes and the leading cause of vision impairment and blindness among working-age adults. It occurs when diabetes damages the tiny blood vessels in the retina, which is the light-sensitive tissue at the back of the eye. Diabetic retinopathy may lead to diabetic macular edema (DME), which is a swelling in an area of the retina called the macula.

### ***Diabetic Retinopathy***

In diabetic retinopathy, the sensitive inner area of the eye is damaged. The two types of diabetic retinopathy are non-proliferative (NPDR) and proliferative (PDR) diabetic retinopathy.

The early stage of the disease that affects fewer blood vessels in the eye leading blurred vision, due to fluid leaks, is known as non proliferative diabetic retinopathy. In majority of the cases it remains like this and may not affect vision. However, in some cases, may involve macula and that may lead to more advanced stage such as proliferative retinopathy.

The fluid leaks are more serious in the proliferative diabetic retinopathy. The pressure in the blood vessels may rupture causing the bleeding. This bleeding is called haemorrhage and this may cause vision loss and scarring of the retina.

Typically, everyone who is above 30 years and has diabetes shows symptoms of diabetic retinopathy. So everyone with diabetes should have regular eye checkups.

## DIABETIC RETINOPATHY

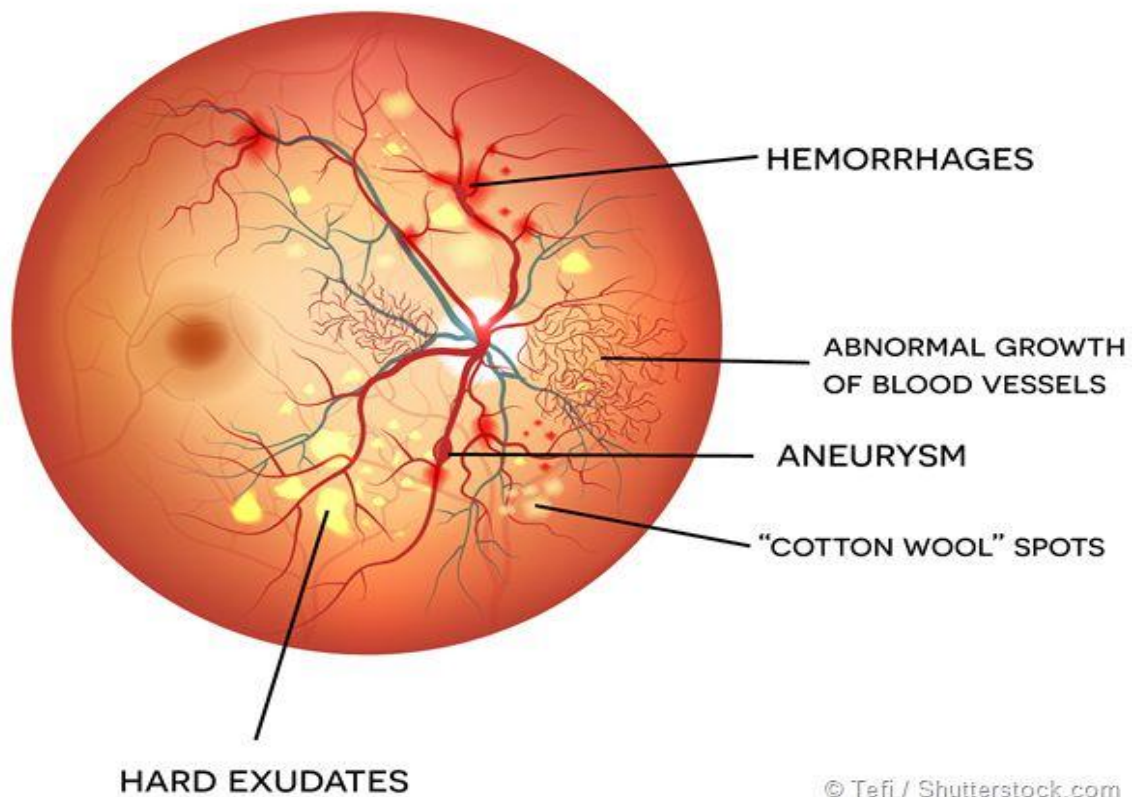


Figure 1-4



## Classification of diabetic retinopathy

Back ground diabetic retinopathy Clinical features

### 1. Micro aneurysms

- Are located in INL are earliest clinically detectable lesions

**sings:** tiny-round, red dots. Initially appearing temporal to the fovea

**F.A:** shows tiny hyper florescent dots.

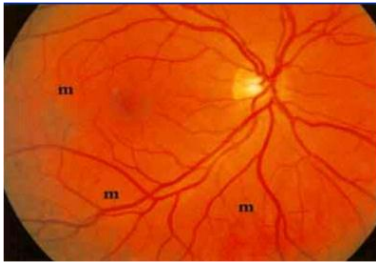


Figure 1-5

### 2. Hard exudates

Lie within the outer plexiform layer .

**sings:** waxy, yellow lesions with relatively distinct margins, often arranged in clumps or rings at the posterior pole .

**F.A:** shows hypofluorescence due to blockage of back ground choroidal fluorescence .

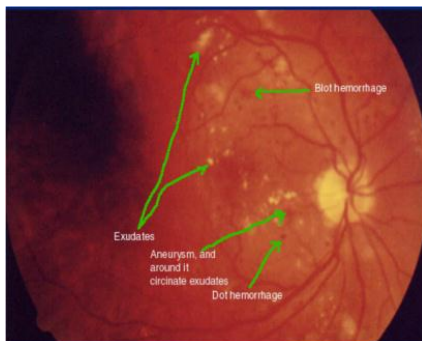


Figure 1-6

### 3. Retinal edema

Is initially located between the outer plexiform and inner nuclear layers.

**Sings** : retinal thickening is best detected

**F.A** : shows diffuse late hyper fluorescence due to retinal capillaries leakage.

### 4. Hemorrhages

- a. Intraretinal hemorrhages: arise from the venous end of capillaries and are located in the compact middle layer of retina with resultant “red dots”.
- b. Retinal nerve fiber layer hemorrhages arise from large superficial pre-capillary arterioles “flame shape”.

## Pre proliferative diabetic retinopathy

### Clinical features

#### 1. Cotton wool spot:

Represent local infarct of retinal nerve fiber due to occlusion of pre-capillary arterioles

**sings**: small, whitish, fluffy superficial lesions which obscure underlying blood vessels.

**F.A**: shows focal hypo fluorescence

#### 2. Inter retinal micro vascular abnormality “IRMA” :

**Sings**: fine redlines that run from arterioles to venues.

**F.A** : shows focal hyper fluorescence.

3. Venous change: consist of dilatation and looping.
- 4 . arterial changes: consisting of narrowing silver-wiring and obliteration .
5. Dark blot hemorrhages .

## Proliferative retinopathy

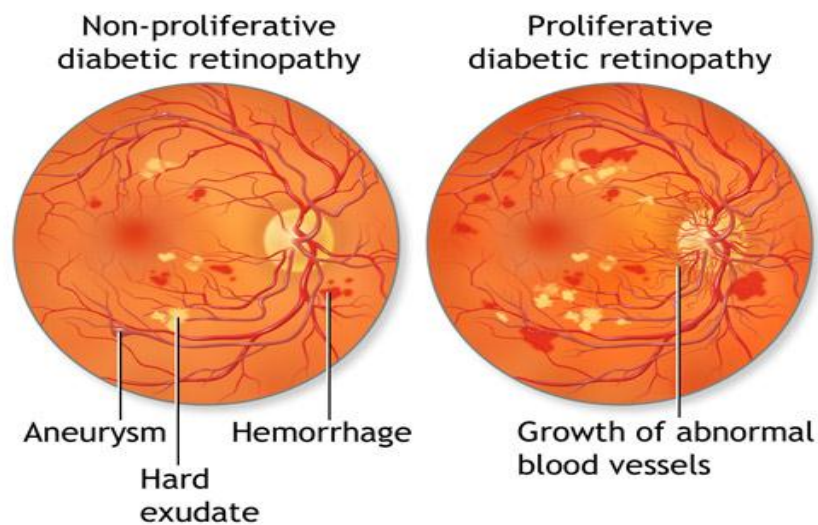


Figure 1-7

ADAM.

### signs :

- new vessels at the disc “NDV”: describes neo vascularization on or with in one disc diameter of the optic nerve head.
- New vessels else where “NVE”:- describes neo-vascularization further away from the disc.

- New vessels on the iris “NVI” also known as rubeosis iridis, may progression to neo-vascular glaucoma.

#### Neo-vascularization at optic disc

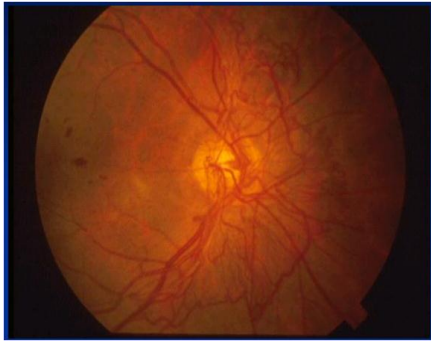


Figure 1- 8

#### Neo-vascularization else where



Figure 1-9

### Advanced diabetic eye disease

- It is the end result of on controlled proliferative D.R. there is marked visual loss.

#### Clinical features

##### 1. Hemorrhage

- May be pre retinal, intrigel or both .
- pre-retinal hemorrhage often has crescent shape which demarcate the level of posterior vitreous detachment .

##### 2. Tractional retinal detachment

- Caused by progressive contraction of fibro-vascular membranes over areas of vitreo-retinal attachment.

### 3. Tractional retinoschisis

This may occur in :

- a) the vitreo-macular traction syndrome.
- b) Proliferative diabetic retinopathy with vitreo-retial traction .

### 4. Rubeosis iridis

## **Risk factors for DR :**

### 1. Duration of diabetes:

- The most important factor, approximately 50% of diabetic patients develop retinopathy after 10 years and about 80% after 15 years. It is seen much more frequently in insulin dependent diabetes mellitus.

### 2. Metabolic control :

Doesn't prevent DR, but delays its progression

### 3. Hypertension .

### 4. Pregnancy .

### 5. Obesity .

### 6. Anemia .

### 7. Smoking .

### **1.3 Problem statement**

The retinal images acquired using low cost fundus camera are prone to various artifacts such as noise , poor image contrast , presence of anatomical structures with highly correlated pixels with that of lesion , illumination variability , color variation of similar subjects due to difference in background , size and shape variation of lesions , and movement of the eye during image acquisition .

## 1.4 Objectives

### General objectives:

To automotive vessels detection with hybrid region information with apply action to retina image

### Specific objectives:

- Identification of abnormal retinal images and detection of major abnormality markers in the retina .
- Early detection clinical decision support .
- Reduce the doctors work load .

## 2.1 Background

An image recognition problem undergoes the following sequence of steps:

1. Image acquisition.
2. Image pre-processing.
3. Image segmentation.
4. Feature extraction.
5. Individual object recognition.
6. Image understanding.

Image acquisition involves formation of an image in an image-capturing device such as a camera. Image pre-processing makes the image more suitable for subsequent processing. Image segmentation can be defined as the process of assigning a label to every pixel in an image. The next step is extraction of suitable features from an image by use of appropriate image processing techniques. Based on features extracted, a classification of individual objects present in an image is undertaken using a classifier. The last step in an image recognition process is image understanding or ‘making sense’ of an ensemble of recognized objects. Here a decision is made of what the image scene is all about based on the recognized objects in the image.

### **Concept of image acquisition :**

An image is formed when light from a source is either reflected or transmitted by a scene (object) and then received by an imaging device. An image therefore, has two components namely, the amount of source illumination present on the scene being viewed, and the amount of illumination reflected by the object in the scene. These are called the illumination and the reflectance components and are denoted by  $i(x,y)$  and  $r(x,y)$ , respectively. The two components combine as a product to form an image. The indices  $x$  and  $y$  are the 2-D spatial coordinates of the image scene.



$$i(x,y) = i(x,y)r(x,y) \quad (2.1)$$

$$\text{Where } 0 < i(x,y) < \infty \quad (2.2)$$

$$\text{And } 0 < r(x,y) < 1 \quad (2.3)$$

Equation 2.3 as a boundary condition indicates that reflectance is zero when absorption is total and 1 when reflectance is total. The nature of  $i(x,y)$  is determined by the illumination source, and  $r(x,y)$  is determined by the characteristics of the objects [8].

### **Concept of image pre-processing:**

The ultimate goal of image pre-processing is to make an image more suitable for subsequent computer processing. There are three main image pre-processing tasks namely: image rescaling, image restoration, and image enhancement. Image rescaling involves either reducing the image size in order to speed up processing and occupy less memory space or increasing the image size for purposes of magnifying some image details. Image restoration involves reducing or eliminating noise from an image while image enhancement is concerned with improving the visual quality of an image [8].

### **Concept of wiener filtering:**

The wiener2 adaptive filter tailors itself to the local image variance *adaptively*. If the variance is large, it minimally smoothes the image. If the variance is small, it performs more smoothing.

This type of filter is effective in reducing the effects of Gaussian white noise.

**Concept of image enhancement:**

The goal of image enhancement is to make an image visually appealing to a human observer. This is a subjective area since the viewer is the ultimate judge of how well a particular method works. A number of image enhancement techniques exist. These include intensity transformation, histogram matching, and histogram equalization amongst others [8], [9].

**Concept of image segmentation:**

Image segmentation involves partitioning a digital image into its constituent regions. The goal of image segmentation is to locate objects and boundaries (lines and curves) in an image. Each of the pixels in a given object in an image share similar characteristics with other pixels belonging to the same object (set). These characteristics include; color, texture, size, orientation, intensity, connectivity etc.

Several image segmentation algorithms and techniques exist. The most commonly used include; morphological image segmentation methods, thresholding based on image histograms, edge detection methods, region growing, and split-and-merge methods [10].

**Binary images: foreground and background:**

A binary image is an image in which each of the pixels assumes one of the only two possible discrete, logical values, 1 or 0. Pixels in binary images having local value 1 are referred to as the image foreground pixels, while those pixels having logical value 0 are called image background pixels. An object in a binary image consists of any group of connected pixels. Two definitions of connections are commonly used. If it is required that the foreground pixel must have at least one neighboring foreground pixel to the north, south, east, or west of itself to be considered as part of the same object, then we are using

4-connection. If however, a neighboring foreground pixel to the north-east, north-west, south-east, or south-west is significant for it to be considered as part of the same object, then we are using 8-connection.

Binary images have no textural content. Thus, the only property of interest in binary images is shape, size and location of the objects in the image. The effect of morphological image processing in binary images reduces simply to the determination of which foreground pixels become background and which background pixels become foreground [11].

### **Concept of edge detection :**

Edges of an image are considered a type of vital information that can be extracted by applying detectors with different methodology [12], [13]. Edge detection is a type of image segmentation techniques that determines the presence of an edge or line in an image and outlines them in an appropriate way. The main purpose of edge detection is to simplify the image data in order to minimize the amount of data to be processed [14], [15]. Generally, an edge is defined as the boundary pixels that connect two separate regions with changing image amplitude attributes such as different constant luminance and tristimulus values in an image [16]–[17]. The detection operation begins with the examination of the local discontinuity at each pixel element in an image. Amplitude, orientation, and location of a particular subarea in the image that is of interest are essentially important characteristics of possible edges [18]–[19]. Based on these characteristics, the detector has to decide whether each of the examined pixels is an edge or not.

### **Concept of feature extraction:**

After an image has been segmented, the resulting aggregate of segmented pixels usually is represented and described in a form suitable for further computer processing. Representing and describing regions involves two choices. An object can be represented and described in terms of its external characteristics (its boundary) or in terms of its

internal characteristics (the pixels comprising the region). After a representation scheme has been chosen, useful data is extracted from the object based on the chosen representation. For example, an object can be represented in terms of its boundary and the boundary described by features such as length, orientation, boundary signature, etc.

An external representation is chosen when the primary focus is on shape characteristics. An internal representation is chosen when the primary focus is on the regional properties, such as color and texture. Sometimes both internal and external descriptors are used for more accurate description of an object. The features selected as descriptors should be as insensitive as possible to variation in size, translation, and rotation [10].

### **Object recognition:**

One of the objectives of image processing is recognition of objects present in an image. The key to successful object recognition lies in selection of appropriate descriptive features of an image. Pattern recognition can be categorized into two principal areas: decision-theoretic and structural. The first category deals with patterns described using quantitative descriptors, such as length, area and texture. The second category deals with patterns best described by qualitative descriptors such as chains, trees, nets and other structural primitives [10].

### **Artificial neural networks (ANNs):**

An artificial neuron is a computational model inspired in the natural neurons. Natural neurons receive signals through synapses located on the dendrites or membrane of the neuron as shown in figure 2-1. When the signals received are strong enough (surpass a certain threshold), the neuron is activated and emits a signal through the axon. This signal might be sent to another synapse, and might activate other neurons.

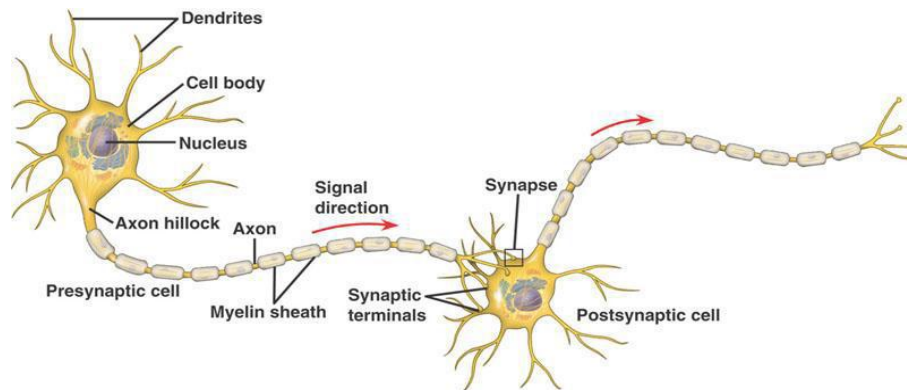


Figure 2-1. Natural neurons.

The complexity of real neurons is highly abstracted when modelling artificial neurons as shown in figure 2-2. These basically consist of inputs (like synapses), which are multiplied by weights (strength of the respective signals), and then computed by a mathematical function which determines the activation of the neuron. Another function (which may be the identity) computes the output of the artificial neuron (sometimes in dependence of a certain threshold). ANNs combine artificial neurons in order to process information.

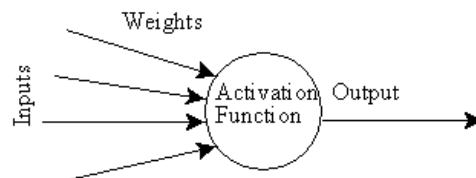


Figure 2-2. An artificial neuron.

An (ANN) is a network of highly interconnecting processing elements (neurons) operating in parallel. Biological nervous systems inspire these elements. As in nature, the connections between elements largely determine the network function. A subgroup of processing element is called a layer in the network. The first layer is the input layer and the last layer is the output layer. Between the input and output layer, there may be additional layer(s) of units, called hidden layer(s) as shown in figure 2-3.

The weights in an ANN express the relative strengths (or mathematical values) of the various connections that transfer data from layer to layer. In other words, the weights express the relative importance of each input to a Processing element[20].

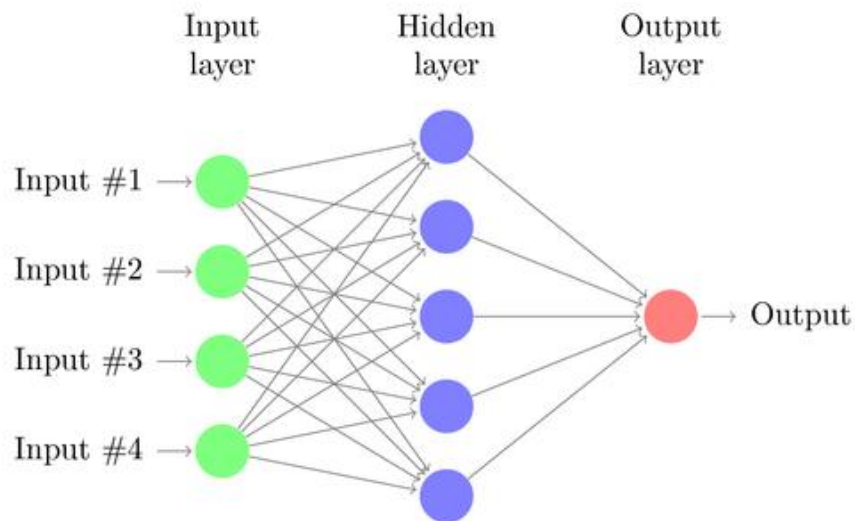


Figure 2-3: Artificial Neural Network.

In situations where statistical properties of pattern class are not known, classification of a decision theoretic problem is best handled by methods that yield the required decision functions directly via training. Neural network is one such approach. It comprises of inter-connections of nonlinear computing elements organized as networks reminiscent of the way neurons are believed to be interconnected in the brain [10].

**Matlab environment:**

Millions of engineers and scientists worldwide use Matlab to analyze and design the systems and products transforming our world. Matlab is in automobile active safety systems, interplanetary spacecraft, and health monitoring devices, smart power grids, and LTE cellular networks. It is used for machine learning, signal processing, image processing, computer vision, communications, computational finance, control design, robotics, and much more.

The Matlab platform is optimized for solving engineering and scientific problems. The matrix-based Matlab language is the world's most natural way to express computational mathematics. Built-in graphics make it easy to visualize and gain insights from data. A vast library of prebuilt toolboxes lets you get started right away with algorithms essential to your domain. The desktop environment invites experimentation, exploration, and discovery. These Matlab tools and capabilities are all rigorously tested and designed to work together. Matlab helps to take ideas beyond the desktop. Analyses can be run on larger data sets and scale up to clusters and clouds. Matlab code can be integrated with other languages, enabling to deploy algorithms and applications within web, enterprise, and production systems.

Information about digital image processing using Matlab and about programming graphics and GUIs with Matlab can be found, for example, in [9] and in [21], respectively. This project, including all functions, segmentation, GUI, image database files, and feature evaluation scripts, have been implemented using Matlab programming environment version R2011. Although we cannot guarantee that, all functions will work properly in older versions of Matlab.

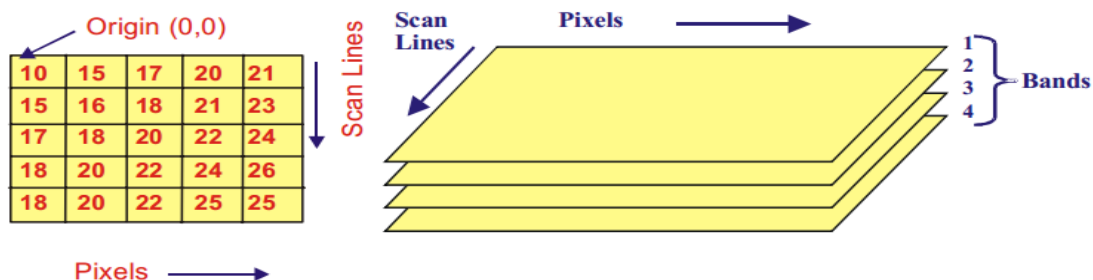
### Digital image processing:

The influence and impact of digital images on modern society is tremendous, and image processing is now a critical component in science and technology. The rapid progress in computerized medical image reconstruction, and the associated developments in analysis methods and computer-aided diagnosis, has propelled medical imaging into one of the most important sub-fields in scientific imaging [22].

Digital image processing deals with manipulation of digital images through a digital computer. It is a subfield of signals and systems but focus particularly on images. DIP focuses on developing a computer system that is able to perform processing on an image. The input of that system is a digital image and the system process that image using efficient algorithms, and gives an image as an output. The most common example is Adobe Photoshop. It is one of the widely used application for processing digital images.

A digital remotely sensed image is typically composed of picture elements (pixels) located at the intersection of each row  $i$  and column  $j$  in each  $K$  bands of imagery. Associated with each pixel is a number known as Digital Number (DN) or Brightness Value (BV), which depicts the average radiance of a relatively small area within a scene. A smaller number indicates low average radiance from the area and the high number is an indicator of high radiant properties of the area [23].

The field of digital image processing refers to processing digital images by means of a digital computer, the depiction of a digital image presented in figure 2-4. Once computer has visual information in appropriate format, computer can analyze it, which is called image analysis. Figure 2-4: Depiction of a digital image.





Digital image processing allows the enhancement of the image's features of interest while attenuating details that are irrelevant in the given context, and then extract or increase the amount of useful information. Such a field of interest with a huge amount of applicability for digital image processing is medicine [8].

The advantages of digital images over analog images are obvious. Digital systems are cheaper, more flexible and information can be shared more easily. The information can be processed and interpreted in most of the cases almost fully automated, and so the speed is highly increased and costs are drastically lowered. Another advantage of digital systems is automatic combination of different acquisitions or/and different techniques in order to obtain more relevant information for human analysis process.

Digital image processing may be subdivided into three groups: preprocessing (low level of processing – preliminary operations used to filter noise, and to eliminate the unnecessary or unwanted details), data reduction (mid-level processing - extraction of useful information, segmentation), feature analysis (high level processing – ensuring semantic meaning extraction) [9].

## 2.2 Related Work

**Ophthalmoscopy or fundus photography:** Ophthalmoscopy is an examination of the retina in which the eye care professional: [3] looks through a slit lamp biomicroscope with a special magnifying lens that provides a narrow view of the retina, or [4] wearing a headset (indirect ophthalmoscope) with a bright light, looks through a special magnifying glass and gains a wide view of the retina. Hand-held ophthalmoscopy is insufficient to rule out significant and treatable diabetic retinopathy. Fundus photography generally captures considerably larger areas of the fundus, and has the advantage of photo documentation for future reference, as well as availing the image to be examined by a specialist at another location and/or time. **Fundus Fluorescein angiography (FFA):** This is an imaging technique which relies on the circulation of Fluorescein dye to show staining, leakage, or non-perfusion of the retinal and choroidal vasculature.

**Optical coherence tomography (OCT):** This is an optical imaging modality based upon interference, and analogous to ultrasound. It produces cross-sectional images of the retina (B-scans) which can be used to measure the thickness of the retina and to resolve its major layers, allowing the observation of swelling.

### 2.3 Literature Review

#### - Their comparative study of two segmentation methods[5]:

**IPACHI** (Infinite Perimeter Active Contour with Hybrid Region Information) Model; It was proposed for the segmentation of objects with Irregular boundaries and so as to integrate hybrid region into the Segmentation model. And **Cauchy kernel** function aimed to prove that the Second method is more effective for achieving a high percentage of Sensitivity, specificity, & accuracy. Their model has been applied to three publicly available retinal datasets Images:

Digital Retinal Images for Vessel Extraction (**DRIVE**), Structured of the Retina (**STARE**), and Vessel Assessment and Measurement Platform for Images of the Retina (**VAMPIRE**).

For DRIVE the **IPACHI** method achieved accuracy, sensitivity, and Specificity:

0.9975, 0.9765, 0.9975 respectively, and the **Cauchy** achieved: 0.9982, 0.9799 And 0.9982 respectively

For STARE the **IPACHI** method achieved accuracy, sensitivity, and Specificity:

0.9975, 0.9686, 0.9975 respectively, and the **Cauchy** achieved: 0.9982, 0.9596 And 0.9982 respectively.

For VAMPIRE the **IPACHI** method achieved accuracy, sensitivity, and Specificity:

0.9975, 0.9123, 0.9975 respectively, and the **Cauchy** achieved: 0.9982, 0.9730 And 0.9982 respectively.

-Their method based on point operators to adjust the illumination Variation, Gabor filter to enhanced the vessels and region growing as Segmentation method to extract the retinal vessels in fundus images. The performance of the proposed methodology is evaluated on the DRIVE database. And their achievements of average Se, Sp, Ppv, Npv, acc are [6].

**0.8163, 0.9704, 0.8343, 0.9609, and 0.9490 respectively.**

-Their study classified the pixels in retinal image with Kohonen's **Self-Organizing Map** (SOM) algorithm. They labeled each neuron in the output Layer of SOM as retinal neuron or non-vessel neuron with Otsu's method, And get the final segmentation results. Their method was validated on the DRIVE database with available gold Standard images.they claimed that their clustering proposed method Achieved a high accuracy percentage of **0.940** as average acc [7].

Image	1	2	3	4	5
Acc	0.946	0.946	0.932	0.943	0.938
Image	6	7	8	9	10
Acc	0.936	0.938	0.937	0.945	0.944
Image	11	12	13	14	15
Acc	0.924	0.946	0.937	0.943	0.944
Image	16	17	18	19	20
Acc	0.940	0.942	0.947	0.955	0.921
Average	<b>0.940</b>				

The goal of this work is to develop a system for diagnosing diabetic retinopathy image, using fundus camera . . This being an image recognition and classification task, a systematic sequence of events was followed to achieve the objective. Generally, the procedure followed in solving such a problem is as follows.

First an image is acquired and pre-processed, it is then segmented into different regions and appropriate features extracted.

Next, a suitable classifier is used to categorize the features into their different classes.

Finally, a decision is made about the information conveyed by the image based on the classes of features found by the classifier.

## 3.1 Flow Chart

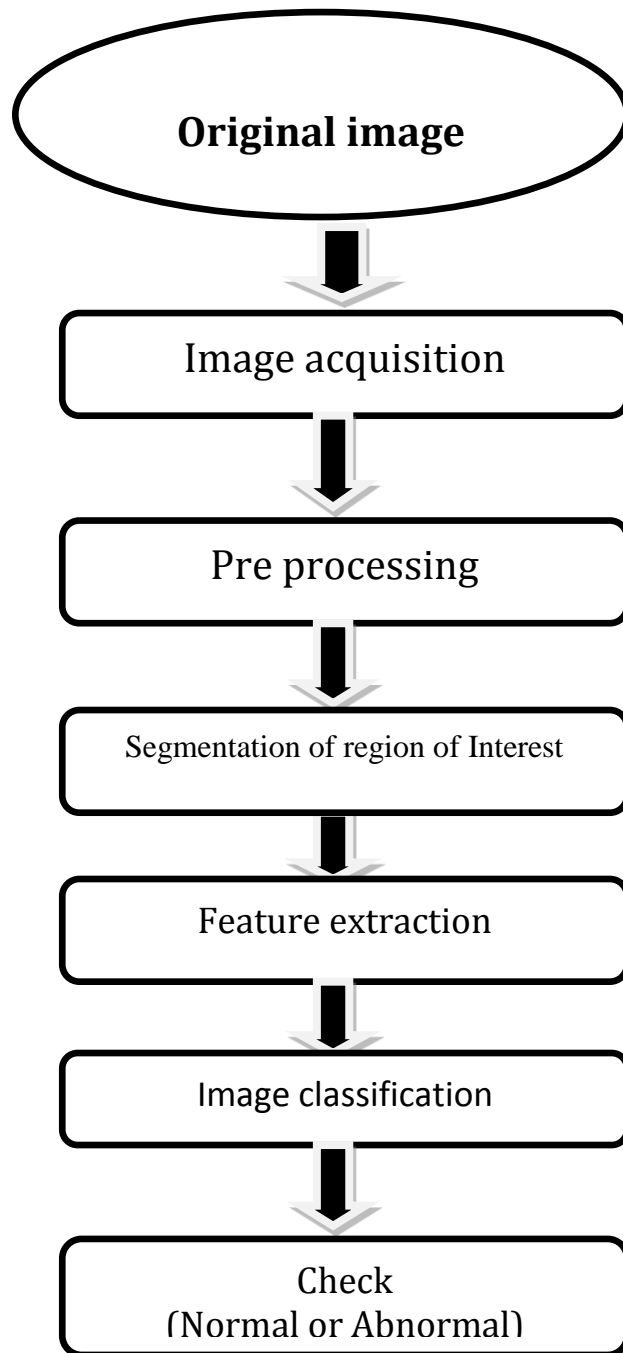


Figure 3-1 flow chart

### 3.2 Data Set

The following publicly available standard data sets have been used in the current work :

- STARE data set Structured Analysis of the Retinal image
- DRIVE data set Digital Retinal Image for Vessel Extraction

Stare and drive images were taken in AL-zrgaa center this images are normal and abnormal but its very little because this center don't save patient data for a long time and the other centers was rejected

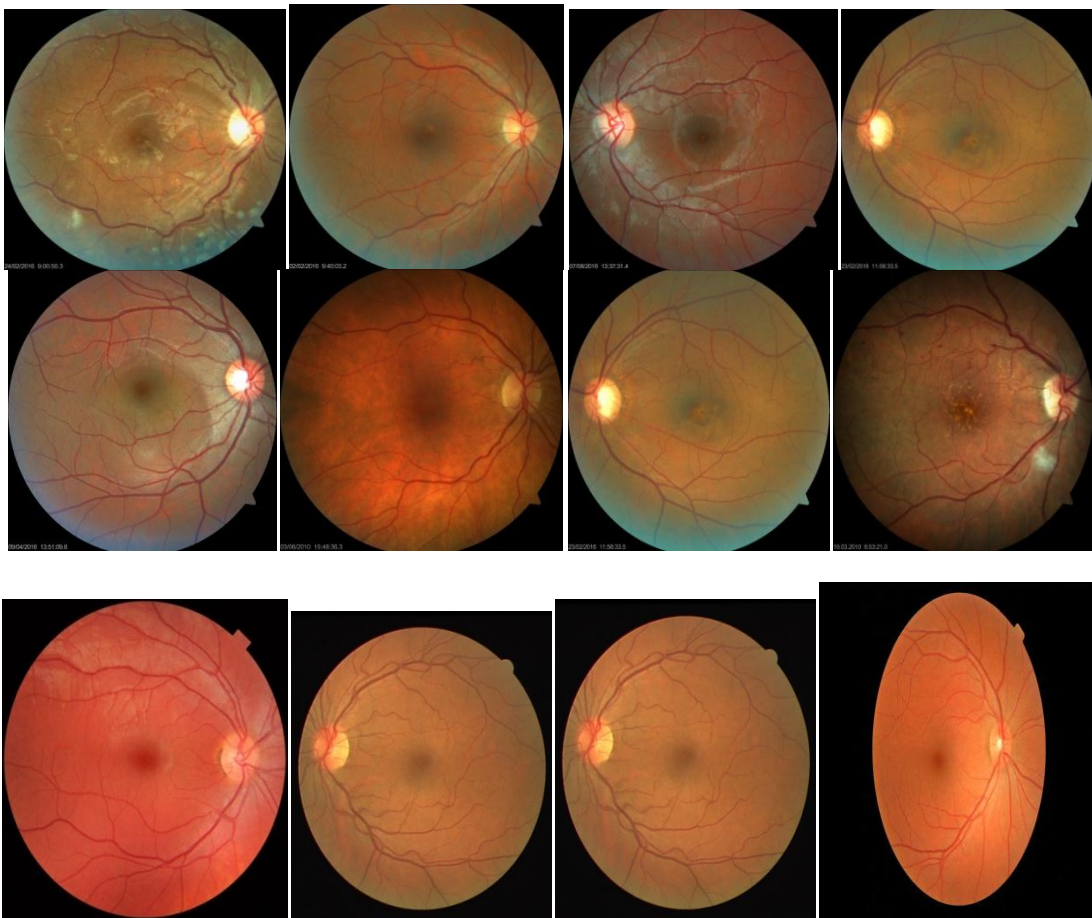


Figure 3-2 data set

### 3.3 Image pre-processing

All RGB images were converted to Gray, Wiener filter was applied to remove Gaussian noise which produced by fundus camera ,and the Histogram was applied to this filtered images .

### 3.4 Image segmentation

Image segmentation is the fundamental step to analyze images and extract data from them. Image segmentation is a mid-level processing technique used to analyze images and can be defined as a processing technique used to classify or cluster an image into several disjoint parts by grouping the pixels to form a region of homogeneity based on the pixel characteristics like gray level, color, texture, intensity and other features [34], [35]. The purpose of the segmentation process is to get more information about the regions of interest in an image, which helps in annotation of the object scene. The main goal of segmentation is to clearly differentiate between the object and the background in an image.

Automatic detection of blood vessels helps measurement and analysis of morphological changes in retinal images Blood vessel detection schemes are roughly divided into two major categories: pixel classification and vessel tracing, most of which use the fluorescein angiography, red-free images, or green channel of color images for analysis. Vessel tracing schemes work by starting from some initial vessel points and trace the vasculature by detection of vessel boundaries and directions [24-33].

### Graphical user interface (GUI)

A graphical user interface (GUI) is a pictorial interface to a program. A good GUI can make programs easier to use by providing them with a consistent appearance and with intuitive controls like pushbuttons, list boxes, sliders, menus, and so forth. The GUI should behave in an understandable andpredictable manner, so that a user knows what to expect when he or she performs an action.



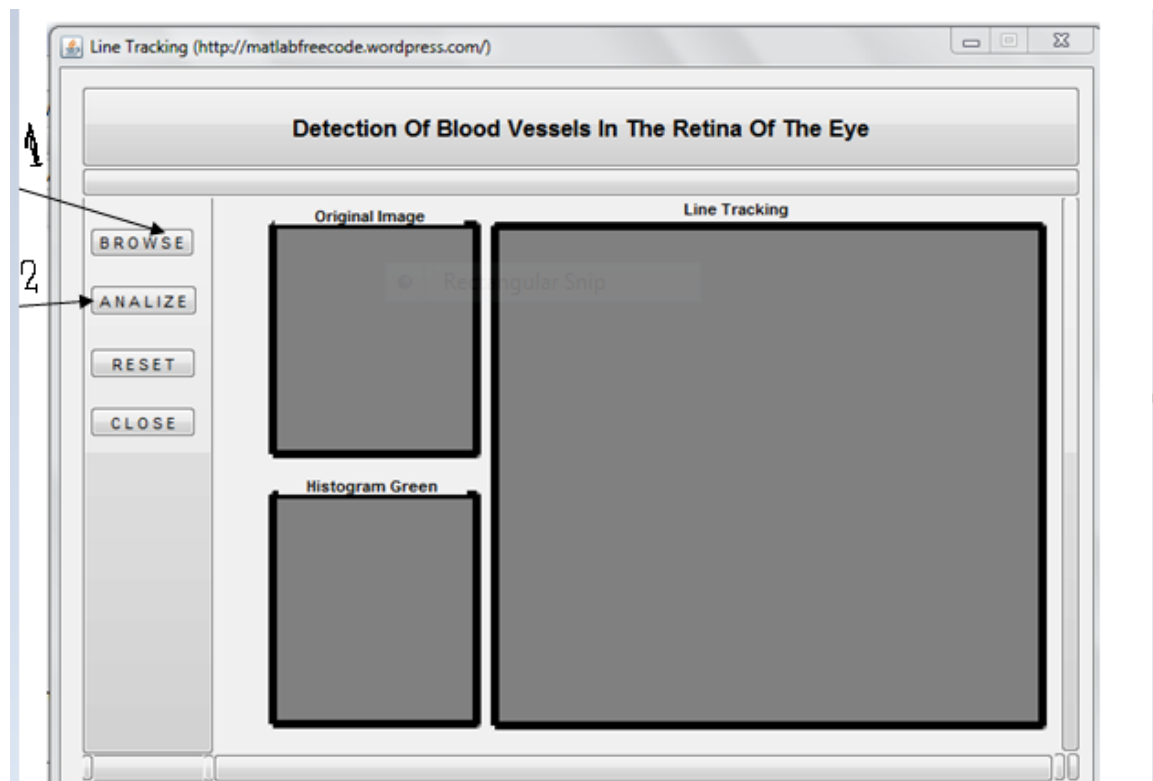


Figure 3-3 GUI

- 1- comes image from folder saved.
- 2- analyze the image to get of segmentation.

### 3.5 Feature Extraction

The feature is defined as a function of one or more measurements, each of which specifies some quantifiable property of an object, and is so computed that it quantifies some significant characteristics of the object. All features can be coarsely classified into low-level features and high-level features. Low-level features can be extracted direct from the original images, whereas high-level feature extraction must be based on low-level features. Texture is a surface property. It is characterized by the spatial distribution

of gray levels in a neighbourhood. Since texture shows its characteristics both by pixel co-ordinates and pixel values, there are many approaches used for texture classification. The image texture depends on the scale or resolution at which it is displayed. A texture with specific characteristics in a sufficiently small scale could become a uniform texture if it is displayed at a larger scale.

The Gray-Level Co-occurrence Matrix (GLCM) seems to be a well-known statistical technique for feature extraction. The GLCM is a tabulation of how often different combinations of pixel gray levels could occur in an image. The goal is to assign an unknown sample image to one of a set of known texture classes. Textural features can be scalar numbers, discrete histograms or empirical distributions. They characterize the textural properties of the images, such as spatial structure, contrast, roughness, orientation, etc and have certain correlation with the desired output.

In pattern recognition and image processing, feature extraction is a special form of dimensionality reduction. When the input data to an algorithm is too large to be processed and it is suspected to be notoriously redundant, then the input data will be transformed into a reduced representation set of features. Transforming the input data into a set of features is called feature extraction. If the features extracted are carefully chosen it is expected that the feature set will extract the relevant information from the input data in order to perform the desired task using the reduced representation instead of the full size input. Features often contain information relative to gray shade, texture, shape or context. To classify an object in an image, we must first extract some features out of the image. [36].

### **Haralick's Features**

The Haralick's texture features are: Energy (EG), Correlation (CO), Inertia (IN), Entropy (EN), Inverse Difference Moment (IDM), Sum Average (SA), Sum Variance (SV), Sum Entropy (SE), Difference Average (DA), Difference Variance (DV), Difference Entropy (DE), Information measure of correlation- 1(ICO-1) and Information measure of correlation-2(ICO-2).These features can be calculated by using the following equations:

**Contrast:**

Contrast measures the quantity of local changes in an image. It reflects the sensitivity of the textures in relation to changes in the intensity. It returns the measure of intensity contrast between a pixel and its neighborhood. Contrast is 0 for a constant image. It is the amount of local variation present in an image. If the amount of local variation is large, the contrast feature also has consistently higher values comparatively. If the gray scale difference occurs continually, the texture becomes coarse and the contrast becomes large. The texture becomes acute if the contrast has a small value.

$$Contrast = \sum_{n=0}^{Nd-1} n_2 \sum_{|i-j|=n} (i, j)$$

**Corelation:**

This feature measures how correlated a pixel is to its neighborhood. It is the measure of gray tone linear dependencies in the image. Feature values range from -1 to 1, these extremes indicating perfect negative and positive correlation respectively. and are the means and and are the standard deviations of ) and ), respectively. If the image has horizontal textures the correlation in the direction of 0° degree is often larger than those in ot her directions. It can be calculated as

$$Correlation = \sum_{i=1}^{N_g} \sum_{j=1}^{N_g} (i - \mu_i)(i, j) / (\sigma_i \sigma_j)$$

Homogeneity :

Homogeneity measures the similarity of pixels. A diagonal gray level co-occurrence matrix gives homogeneity of 1. It becomes large if local textures only have minimal changes.

$$\text{Homogeneity} = \sum_{i=1}^{N_g} \sum_{j=1}^{N_g} P(i, j) / 1 + |i - j|$$

Energy :

Energy also means uniformity, or angular second moment (ASM). The more homogeneous the image is, the larger the value. When energy equals to 1, the image is believed to be a constant image.

$$\text{Energy} = \sum_{i=1}^{N_g} \sum_{j=1}^{N_g} Pd(i, j)^2$$

Entropy is a measure of randomness of intensity image.

$$\text{Entropy} = - \sum_{i=1}^{N_g} \sum_{j=1}^{N_g} (i, j) \log(Pd(i, j))$$

$N_g$  is Number of distinct gray levels in quantized image.

Energy, entropy, contrast, homogeneity and correlation features are often used among the 14 Haralick texture features to reveal certain properties about the spatial distribution of the texture image. Since real textures usually have so many different dimensions, these texture properties are not independent of each other. For instance, the energy measure generated from gray level co-occurrence matrix is also known as homogeneity and variance is a measure of contrast in images. Therefore, when choosing a subset of meaningful features from gray level co-occurrence matrix for a particular application, features do not have to be independent because a subset of fully independent features is usually hard to find. Haralick illustrated the applications of

some textural features computed based on co-occurrence matrices. He employed distance co-occurrence matrices to compute angular second moment, contrast, correlation and entropy for categorization tasks for several kinds of images. The features computed based on the co-occurrence matrices have a general applicability for different kinds of images.

### 3.6 Image Classification

#### **Artificial neural network (ANN) classification**

NPRTOOL command was used to generate a MATLAB script which solves a Pattern Recognition problem with a Neural Network and it uses back propagation algorithm. In the script, firstly the input and target data was defined. The input data is a matrix with dimension of 736 x 3 which represents the selected features, and the target data is a matrix of 2 x 736 and contains zeros and ones only with respect to normal and abnormal features in the input matrix. The hidden layers was set to 20 then the network training was done using MATLAB<sup>TM</sup> function train which it's input is the created hidden layer, input data, and the target, then network was tested and its performance was found. The command view was used to view the network windows and finally the network was saved as Test.mat. The previous illustrated network that was created was running all of time as training process of the network until a suitable accuracy was acquired.

## 4.1 Segmentation Result:

### Graphical user interface (GUI)

A graphical user interface (GUI) is a pictorial interface to a program. A good GUI can make programs easier to use by providing them with a consistent appearance and with intuitive controls like pushbuttons, list boxes, sliders, menus, and so forth. The GUI should behave in an understandable and predictable manner, so that a user knows what to expect when he or she performs an action.

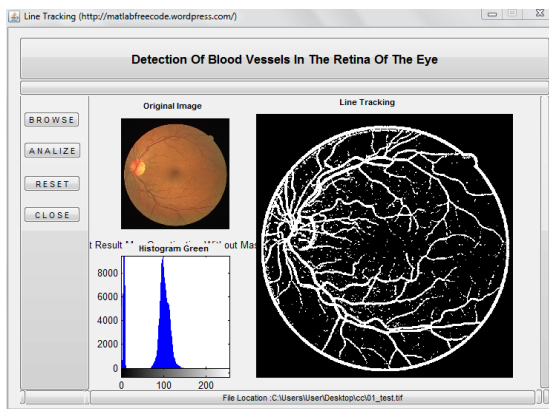


Figure 4-1: GUI after run the algorithm & Segmentation result

**4.2 Feature Result**

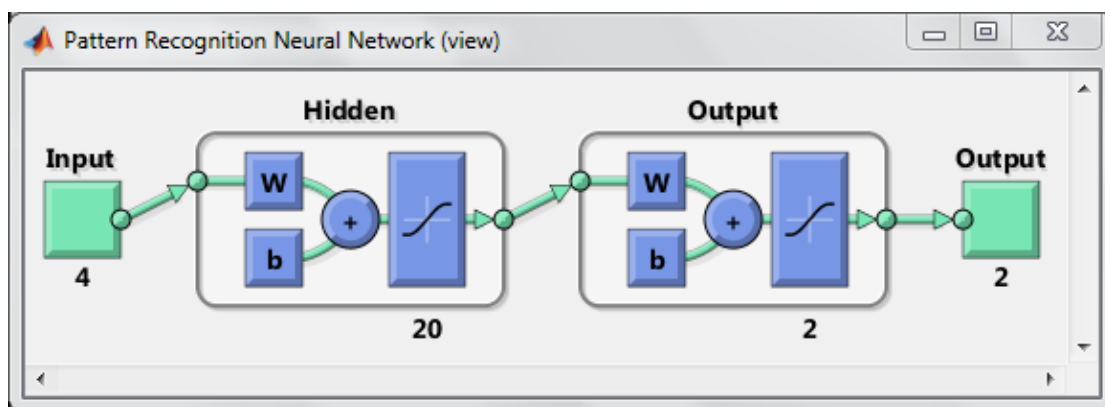
Table 4.1

Image No	correlation	energy	Homogeneity	Contrast
1	0.8515	0.8539	0.9855	0.1838
2	0.8253	0.9411	0.9911	0.0868
3	0.8489	0.8341	0.9767	0.2446
4	0.8206	0.8403	0.9827	0.1468
5	0.8127	0.8914	0.9874	0.1242
6	0.8392	0.9421	0.9939	0.065
7	0.8552	0.9207	0.9925	0.0589
8	0.8139	0.9688	0.9963	0.0228
9	0.8615	0.9454	0.9944	0.0439
10	0.8624	0.9592	0.9961	0.0583
11	0.8715	0.9373	0.9944	0.0596
12	0.8577	0.7788	0.9781	0.2898
13	0.8554	0.8048	0.9809	0.2182
14	0.8638	0.8081	0.9805	0.3026
15	0.8451	0.8103	0.9792	0.3185
16	0.8696	0.8424	0.9855	0.1566

### 4.3 Artificial Neural Network (ANN) Results

In ANN many windows and graphs appear when running it which clarify the architecture of the network that was created. Two windows are opening immediately after running the created network the first one is the neural network training which illustrates the neural network architecture, algorithm that used, progress, and plots that can show. The next window that will next appears is the pattern recognition neural network architecture, in this case there are two input set to get two output set also (normal and abnormal), and the hidden layers were set to be 20 layers as recommended in chapter Three. Then from the neural network window four figures were plotted by checking in their icon which are: performance, training state, error histogram, and confusion matrix.

Figure 4.2 shows Neural Network Architecture.





#### 4.4 Results of image classification

Features that selected to represent the data as normal and abnormal. For classification both of developed algorithm and ANN classification techniques were used and the accuracy and performance of each of them were calculated.

##### Performance Evaluation of Classification

The performance of both classification methods was calculated using the below statistical terms:

A true positive (TP): Results when a test indicates a positive status when the true status is also positive.

A true negative (TN): Results when a test indicates a negative status when the true status is also negative.

A false positive (FP): Results when a test indicates a positive status when the true status is negative.

A false negative (FN): Results when a test indicates a negative status when the true status is positive.

The sensitivity of a test (or symptom): Is the probability of a positive test result (or presence of the symptom) given the presence of the disease.

$$\text{Sensitivity} = \frac{TP}{TP + FP} \times 100 \quad (4.1) \text{ probability of a negative test result}$$

(or absence of the symptom) given the absence of the disease. **specificiity** =

$$\frac{TN}{TN + FN} \times 100 \quad (4.2) \quad \text{d value is to the actual (true) value.}$$

$$\text{Accuracy} = \frac{\text{Number of Correct Data}}{\text{Number of All Data}} \times 100 = \frac{TP + TN}{\text{TOTAL}} \times 100 \quad (4.3)$$

	<b>Abnormal</b>	<b>Normal</b>	<b>Total</b>
<b>Positive</b>	<b>11</b> (TP)	<b>0</b> (FN)	<b>11</b>
<b>Negative</b>	<b>0</b> (FP)	<b>5</b> (TN)	<b>5</b>
<b>Total</b>	<b>11</b>	<b>5</b>	<b>16</b>

From table 4.2, **TP = 11, FP = 0, FN = 0, TN =5, Total = 16**, and by applying in the above equation:

$$\text{Sensitivity} = \frac{TP}{TP + FP} \times 100 = 11 / (11+0)$$

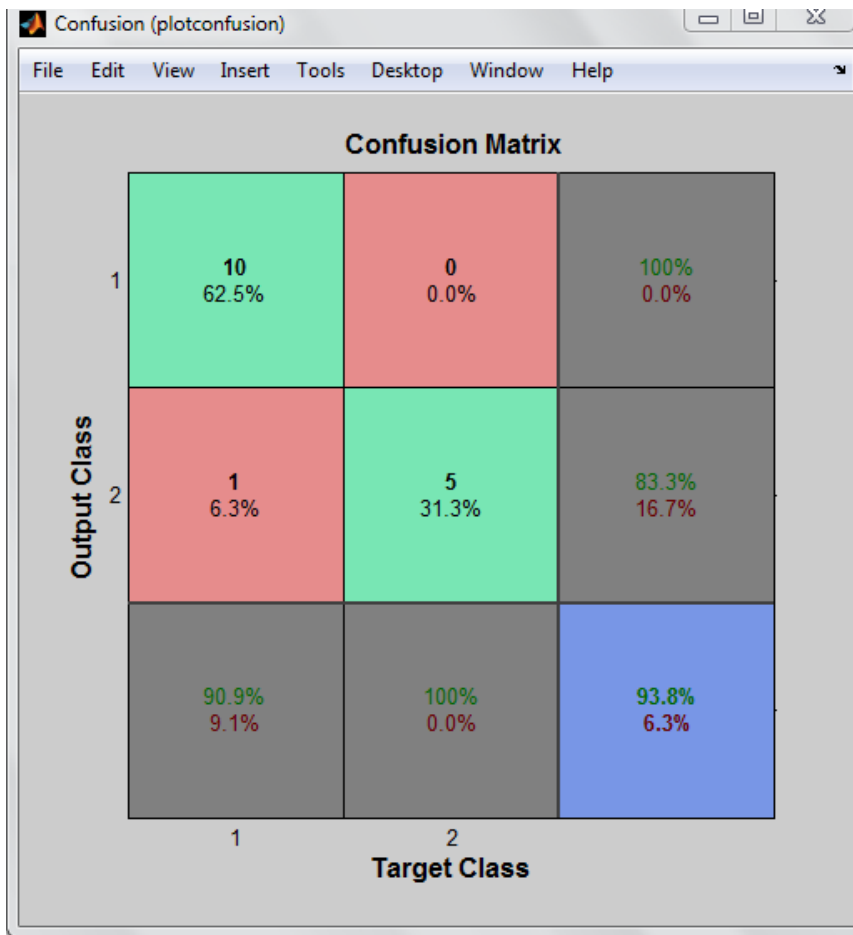
**=100%**

$$\text{specificiity} = \frac{TN}{\text{StatusResult}} \times 100 = 5 / (5+0) = 100\%$$

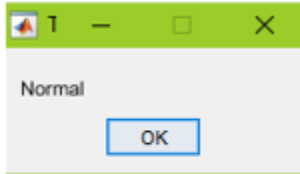
$$\text{Accuracy} = \frac{\text{Number of Correct Data}}{\text{Number of All Data}} \times 100 = \frac{TP + TN}{\text{TOTAL}} \times 100 = 16/16 = 100\%$$

It is clear that from the performance evaluation of the ANN the accuracy is (93.8 %) which means artificial neural network gives more accurate result for the data used in this study. Therefore, for final classification step ANN classification method was chosen and applied in the proposed system

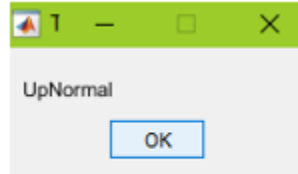
Figure (4.3): classification of images using ANN



The messages which illustrated in figure 4-9 is final result of the classification step.



**a**



**b**

Output messages a.fig (4.4) Normal, b. Up-normal.

Table 2 (4.3)

Image No	Classification
1	Abnormal
2	Abnormal
3	Abnormal
4	Abnormal
5	Abnormal
6	Abnormal
7	Abnormal
8	Abnormal
9	Abnormal
10	Abnormal
11	Abnormal
12	Normal
13	Normal
14	Normal
15	Normal
16	Normal

## 5-1 CONCLUSION

This thesis proposes a retinal vessel segmentation method based on neural network .TO automotive vessels detection with hybrid region information with apply action to retina image.

We detect the blood vessels by the segmentation , filtered this blood vessels segmentation ,we measure haralick feature , recorded this measured value , and we used this value to measured accuracy and Then we classify the retinal images in normal and abnormal images .

## 5-2 Discussion

Experiments were held on atotal 5 samples of normal retinal images,and 11 samples of abnorml retinal images .As demonstrated in table[2] The experimental tests have areal results .this results are very helpful to automotive vessels detection .

## 5-3 Recommendation

- next studies could improve our proposed study using image enhancement & segmentation to detect retinal blood vessels occolusion instead of fluoroscopy
- increase the quantity of imges to get a high accuracy value.

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