PROJECT REPORT ON

AUTOMATIC DETECTION OF DIABETIC RETINOPATHY

USING IMAGE PROCESSING ALGORITHMS

UNDER THE GUIDANCE OF

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4TH YEAR (8TH SEMESTER)

ELECTRONICS & COMMUNICATION ENGINEERING DEPARTMENT

KALYANI GOVERNMENT ENGINEERING COLLEGE

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তারিখ / Date :

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Kalyani Government Engineering College
(Govt. of West Bengal)

Certificate of Approval

This is to certify that this report of B. Tech final year project entitled "**AUTOMATIC DETECTION OF DIABETIC RETINOPATHY using image processing algorithms**" is a record of bona-fide work, carried out by **BRIJESH MONDAL(10200310006), PRANSHU CHAKRABORTY(10200310004), JOYDIP PANJA(10200310008), KANU SOREN(10200311068)** under the able guidance of **Prof. Himadri Sekhar Dutta.**

In my opinion, the report in its present form is in fulfilment of all the requirements, as specified by the **Kalyani Government Engineering College** and as per regulation of the **West Bengal University of Technology**. In fact, it has attained the standard, necessary for submission. To the best of my knowledge the results embodied in this report, are original in nature and worthy of incorporation in the present version of the report for B.Tech program in **Electronics & Communication Engineering**.

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ABSTRACT

This project applies the process and knowledge of digital signal processing and image processing to diagnose diabetic retinopathy from images of retina using MATLAB 2013a. The Processing stage equalizes the uneven illumination associated with raw images and also removes noise present in the image. Segmentation stage clusters the image into two distinct classes while the Disease Classifier stage was used to distinguish between candidate lesions and other information. Method of diagnosis of red spots, bleeding and detection of vein-artery crossover points were also developed in this work using the color information, shape, size, object and length to breadth ratio as contained in the digital fundus image in the detection of this disease.

ACKNOWLEDGEMENT

The success of any project depends largely on the encouragement and guidelines of many others, apart from the group members. We take this opportunity to express our gratitude to the people who have been involved in the successful completion of our project.

We take this opportunity to express my profound gratitude and deep regards to our guide Dr. Himadri Sekhar Dutta, Assistant Professor, Kalyani Government Engineering College for his exemplary guidance, monitoring and constant encouragement throughout the course of this project. The blessing, help and guidance given by him time to time shall carry us a long way in the journey of life on which we are about to embark.

The guidance and support received from all the members who contributed and who are contributing to this project, was vital for the success of the project. We are grateful for their constant support and help.

Contents

MOTIVATION

Diabetic retinopathy (DR) can be defined as damage to microvascular system in the retina due to prolonged hyperglycemia. However, due to the large number of diabetic subjects, DR is likely to pose a public health burden in India. A huge increase of DR in people at risk for the worst complications of chronic illness with too few specialists to provide regular screening and identify people in imminent danger of permanent vision loss.

Despite physician recommendations that people with diabetes obtain annual dilated retinal examinations to detect sight-threatening lesions, only approximately half of all known diabetics currently receive this standard of care. For many in underserved areas of the country, and for many more who do not recognize the risks or who do not have the financial ability to pay for conventional care delivery, diabetic retinopathy threatens to deprive them of their vision and a productive and fulfilling life.

Digital detection of diabetic retinopathy is a technological means of bridging the gap between recommendations and actual access to healthcare. It will be able to reach patients who would not otherwise obtain dilated retinal examinations.

Automatic detection of diabetic retinopathy using digital imaging and telemedicine is a useful addition to conventional physician screening. It overcomes time, money, and logistical constraints, improves access, reduces disparities, provides equity of care, and improves outcomes, and may be beneficial even in the case of current unprecedented increases in newly diagnosed cases of diabetes.

So, we are trying to develop a system which can take a picture of eye of a patient and automatically diagnosis whether a patient have DR or not. This may be beneficial for the current situation of India.

INTRODUCTION

All patients with diabetes mellitus will have a higher risk of being diagnosed with diabetic retinopathy. In Singapore & India like third world countries, 22% of patients are diagnosed with diabetic retinopathy and half of this affected patients had severe sight-threatening diseases.

Diabetic retinopathy happens when the tiny blood vessels are damaged. These blood vessels are responsible for providing nutrients and oxygen to the retina. As shown in Figure 1, the person with diabetic retino -pathy does not have a clear vision of the surround - ings. Thus, he will face numerous problems and difficulties in his daily life routine. When his conditions become more severe, he will gradually lose his vision. Hence, early diagnosis or treatment will be able to prevent blindness complicated by diabetic retinopathy. In order to prevent loss of vision, periodic eye-examination is necessary to check for any early warning signs. If diabetic retinopathy is detected at an early stage, laser treatment is usually performed to delay the progression of the disease.

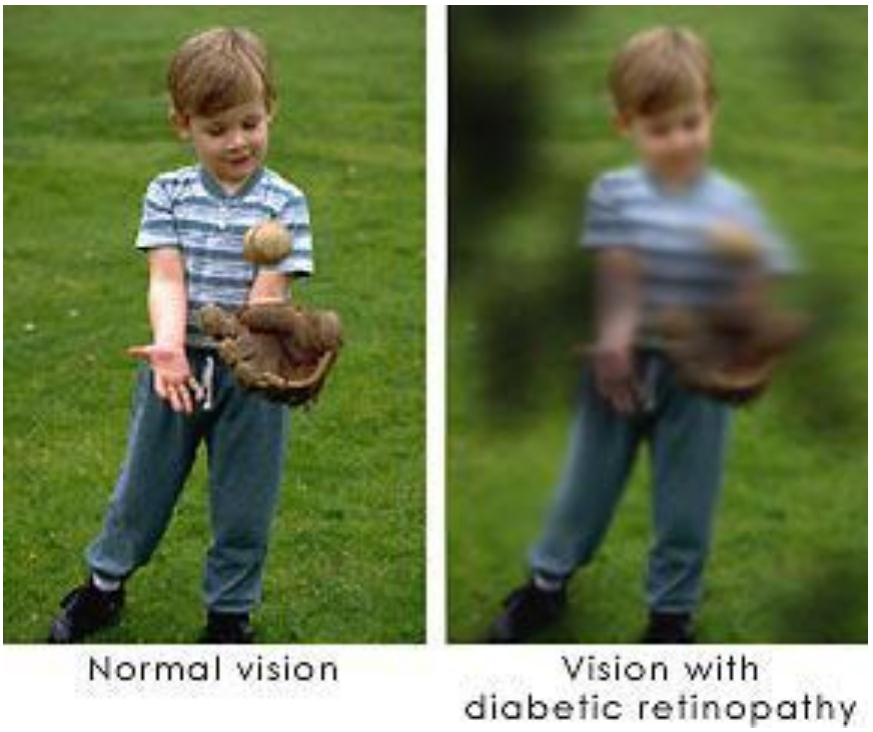


Figure 1: Normal vision and vision with diabetic retinopathy

EYE ANATOMY

The anatomy of the human eye is shown in given figure. When light enters the pupil, the lens will focus it and then detected by the retina. The amount of light entering the eye will be regulated by the iris. The movement of the iris is controlled by the contraction and relaxation of the ciliary muscle. The retina contains light-sensitive receptors consisting of rods and cones. As rods are more sensitive and require less light to function, they are used mostly in the night or dim places with poor visibility. Unlike the characteristic of rods, cones are less sensitive and are normally used in daylight for perception of colour. Upon detected by the retina, electrical signal will be delivered to the brain by the optic nerve. Finally, these impulses will be translated into images that we perceived. The macula is located in the centre of the retina and this is responsible for providing a central vision. Also, the fovea is located within the macula and this location provides the sharpest vision and colour perception.

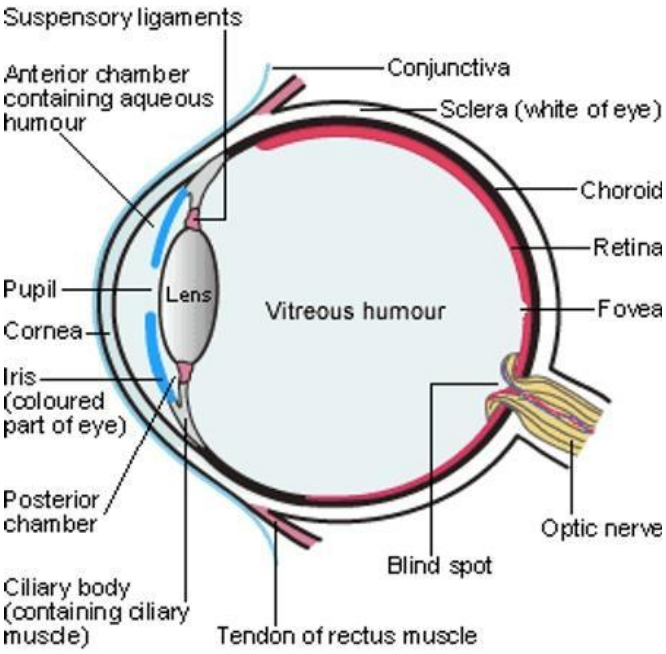


Figure 2:Human Eye Structure

DIABETIC RETINOPATHY

The effect of diabetes on the eye is called Diabetic Retinopathy (DR). It is known to damage the small blood vessel of the retina and this might lead to loss of vision. The disease is classified into two stages:

1. *Non-Proliferative or Background Diabetic Retinopathy*
2. *Proliferate Diabetic Retinopathy*

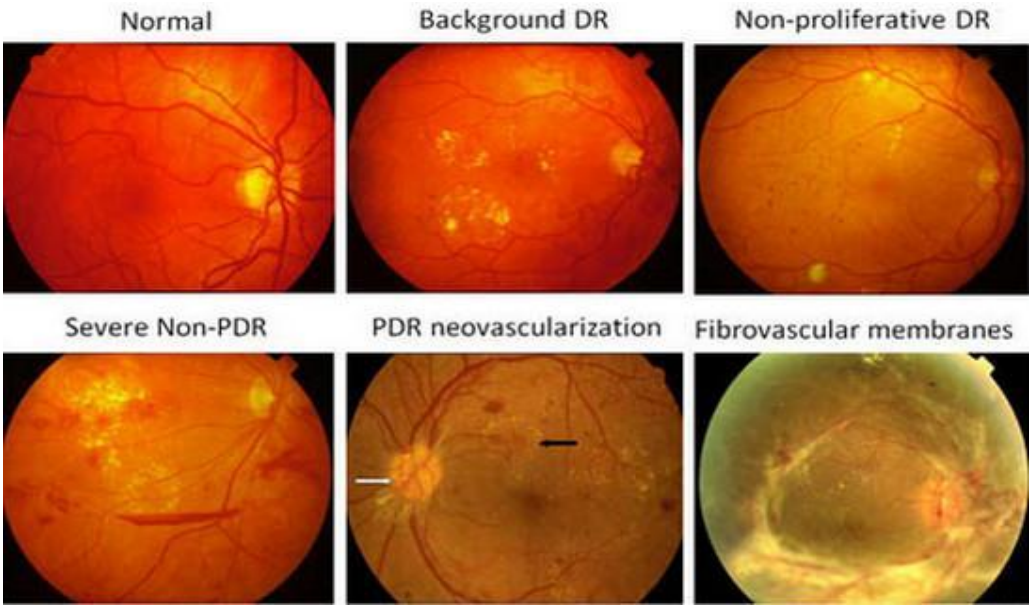


Figure 3: Stages of Diabetic Retinopathy

Non-proliferative diabetic retinopathy occurs when there are only intraretinal microvascular changes, such as altered retinal vascular permeability and eventual retinal vessel closure. Clinically, the hallmark of the non-proliferative phase is microaneurysms and intraretinal abnormalities. Neovascularization is not a component of the non-proliferative phase. However, in advanced NPDR, nonperfusion of the retina may develop and lead to the proliferative phase. Proliferative diabetic retinopathy is characterized by new vessels and sometimes fibrous bands proliferating on the retinal surface. In both nonproliferative and proliferative

diabetic retinopathy, macular edema can occur as increased retinal vascular permeability leads to accumulation of fluid in the retinal area serving central vision.

Proliferative diabetic retinopathy continues to be a major cause of blindness throughout the world. The natural history demonstrates that its development is primarily related to progressive retinal ischemia from diabetic retinopathy. The primary complications leading to vision loss, tractional retinal detachment and vitreous hemorrhage, are dependent upon the relationship between the neovascular tissue and the vitreous.

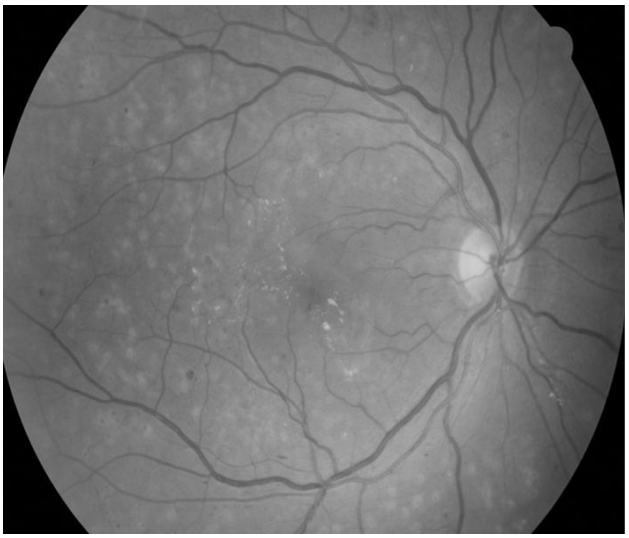


Figure 4:a. Non-Proliferative DR

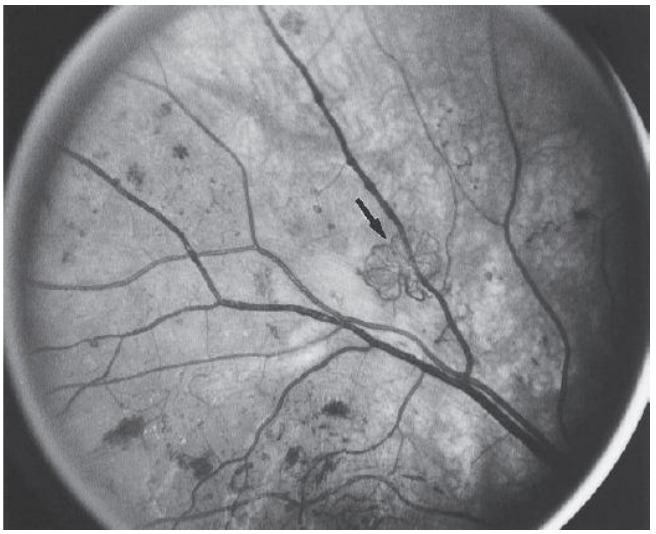


Figure 4:b.Proliferative DR

ABNORMALITIES ASSOCIATED WITH THE EYE

Abnormalities associated with the eye due to Diabetic Retinopathy can be divided into five different forms. If not properly treated, DR might eventually lead to loss of vision.

Ophthalmologists have come to agree that early detection and treatment is the best treatment for this disease. Diabetic Retinopathy can occur in any of the form described below as related to this research work.

Microaneurysms: These are the first clinical abnormality to be noticed in the eye. They may appear in isolation or in clusters as tiny, dark red spots or looking like tiny hemorrhages within the light sensitive retina. Their sizes ranges from 10-100 microns i.e. less than 1/12th the diameter of an average optics disc and are circular in shape. At this stage, the disease is not eye threatening.

Hemorrhages: Occurs in the deeper layers of the retina and are often called 'blot' hemorrhages because of their round shape.

Hard Exudates: These are one of the main characteristics of diabetic retinopathy and can vary in size from tiny specks to large patches with clear edges. As well as blood, fluid that is rich in fat and protein is contained in the eye and this is what leaks out to form the exudates. These can impair vision by preventing light from reaching the retina.

Soft Exudates: These are often called 'cotton wool spots' and are more often seen in advanced retinopathy.

Neovascularization: This can be described as abnormal growth of blood vessels in areas of the eye including the retina and is associated with vision loss. This occurs in response to ischemia, or diminished blood flow to ocular tissues. If these abnormal blood vessels grow around the pupil, glaucoma can result from the increasing pressure within the eye.

These new blood vessels have weaker walls and may break and bleed, or cause scar tissue to grow that can pull the retina away from the back of the eye. When the retina is pulled away it is called a retinal detachment and if left untreated, a retinal detachment can cause severe vision loss, including blindness. Leaking blood can cloud the vitreous (the clear, jelly-like substance that fills the eye) and block the light passing through the pupil to the retina, causing blurred and distorted images. In more advanced proliferate retinopathy; diabetic fibrous or scar tissue can form on the retina.

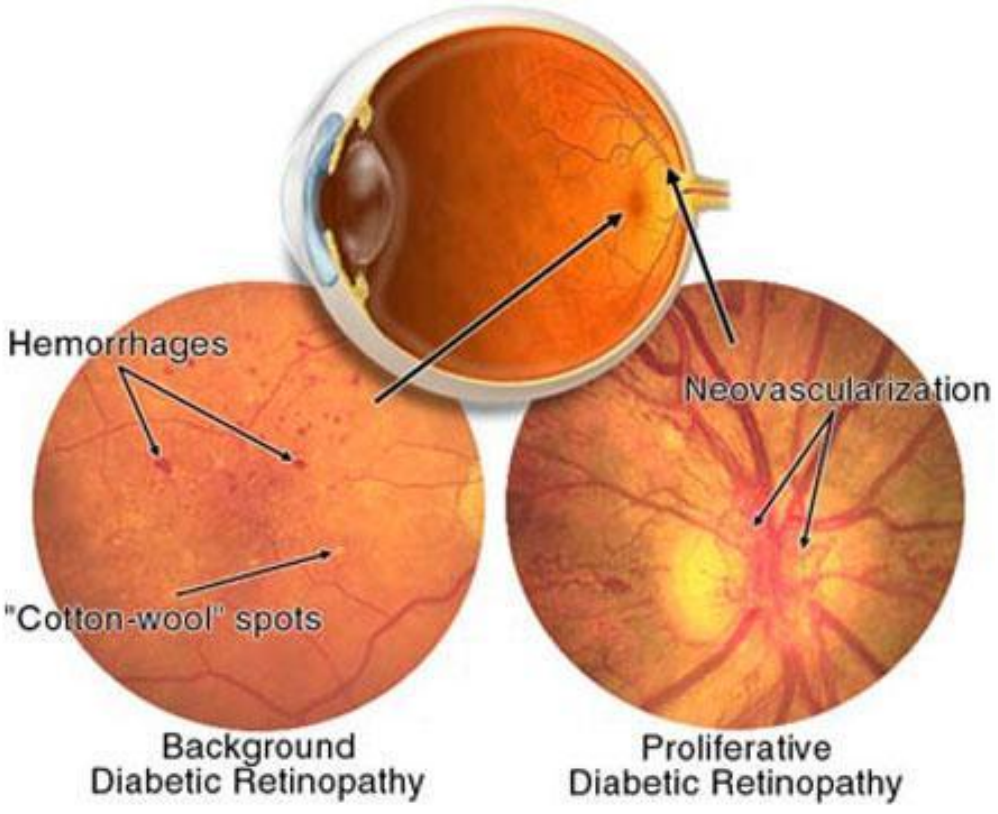


Figure 5: Abnormalities due to Diabetic retinopathy

REVIEW WORK AND PRE-PROCESSING STEPS

IMAGE PROCESSING: We can think of an image as a function, f, from R2 to R:

f(x,y) gives the intensity at position (x, y).
Realistically, we expect the image only to be defined over a rectangle, with a finite range:
f: [a,b]x[c,d] à[0,1]
A color image is just three functions pasted together. We can write this as a vector-valued function:

COLOR SPACE CONVERSION: A common strategy is to match the luminance of the grayscale image to the luminance of the color image. To convert any color to a grayscale representation of its luminance, first one must obtain the values of its red, green, and blue (RGB) primaries in linear intensity encoding, by gamma expansion. Then, 30% of the red value, 59% of the green value, and 11% of the blue value is added together. Colours in an image may be converted to a shade of gray by calculating the effective brightness or luminance of the colour and using this value to create a shade of gray that matches the desired brightness. The effective luminance of a pixel is calculated using the formula,

$$Y = 0.21\ R + 0.71\ G + 0.07\ B.$$

This luminance value can then be turned into a grayscale pixel. A grayscale digital image is an image in which the value of each pixel is a single sample, that is, it carries only intensity information.

ZERO-PADDING: The result of this color space conversion section is fed to the edge padding section of PPS. In this subsection, the image is padded with zeros so as to remove unwanted noise that may be introduced during the intensity enhancement and segmentation stage and also to be able to calculate the minimum and maximum intensity value of the whole image.

There are four steps associated with this section, viz. image intensity thresholding, image fillings and minimum and maximum intensity detection.

HISTOGRAM EQUALIZATION: Histogram equalization is nothing but a finding of cumulative distribution function for a given probability density function. Modeling of the histogram is usually done by the use of continuous process functions rather than discrete process functions. Suppose for a given image the intensity levels are continuous quantities and is normalized to the range [0 1]. According to Gonzalez and Woods [2002], transformation can be performed on the probability density function of the intensity levels input image Pr(r) is to obtain S as shown below where ω is the dummy variable of integration.

After the transformation, the image will have an increased dynamic range, high contrast and the probability density function of the output will be uniform, which can be regarded as a Cumulative Distribution Function (CDF).
Ps (s) = 1 for $0 \leq s \leq 1$, else zero.

In digital images, the intensity levels are discrete in nature, so the method above is often

$$S_k = T(r_k) = \sum_{j=1}^{k} P_r(r_j) = \sum_{j=1}^{k} \frac{n_j}{n}$$

referred to as histogram equalization method, though the output image histogram is not uniform due to the discrete nature of the variables. For discrete value data, the summations and equalization methods above become for j = 1,2,……..L, where s_k is the intensity value in the output (processed) image corresponding to the value r_k in the input image. Example of this is as shown below

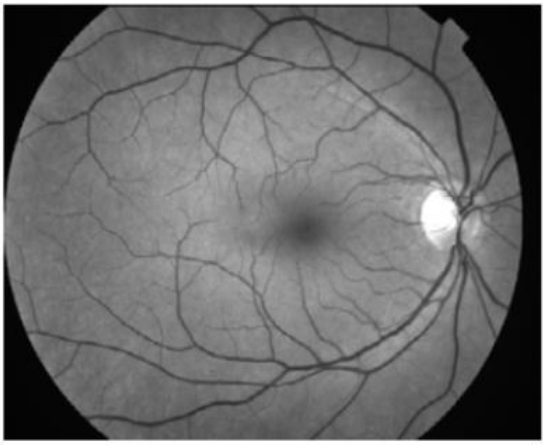


Figure 6:a. Input Image

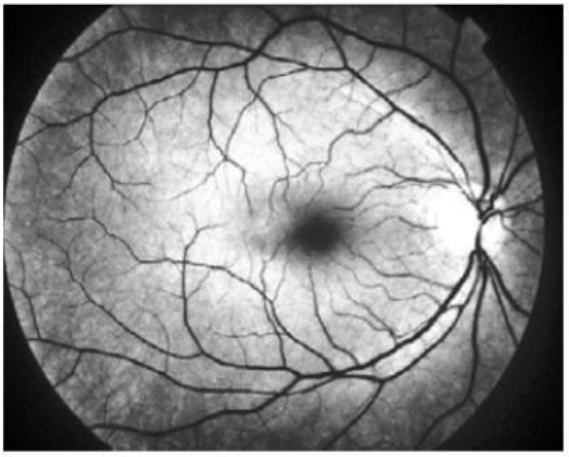


Figure 6:b.Output Image

ADAPTIVE HISTOGRAM EQUILIZATION

The main objective of this method is to define a point transformation within a local fairly large window with the assumption that the intensity value within it is a stoical representation of local distribution of intensity value of the whole image. The local Window is assumed to be unaffected by the gradual variation of intensity between the image centres and edges. The point transformation distribution is localized around the mean intensity of the window and it covers the entire intensity range of the image. Consider a running sub image W of N x N pixels centered on a pixel P(i,j), the image is filtered to produce another sub image P of (N x N) pixels according to the equation below

$$p_n = 255.\left(\frac{\left[\phi_w(p) - \phi_w(Min)\right]}{\left[\phi_w(Max) - \phi_w(Min)\right]} \right)$$

Where,

$$\phi_w(p) = \left[1 + \exp\left(\frac{\mu_w - p}{\sigma_w} \right) \right]^{-1}$$

and Max and Min are the maximum and minimum intensity values in the whole image, while μ_w and σ_w indicate the local window mean and standard deviation which are defined as:

$$\mu_w = \frac{1}{N^2} \sum_{(i,j)\in(k,l)} p(i,j)$$

$$\sigma_w = \sqrt{\frac{1}{N^2} \sum_{(i,j)\in(k,l)} \left(p(i,j) - \mu_w\right)^2}$$

MORPHOLOGICAL FILTERING

Morphological operations are a set of image processing operations that analyzes the shapes within the image. It applies a structuring element to the image and output the image of the same size. The output value of each pixel is determined by the neighboring pixels with its corresponding pixel of input image. The size and shape of the structuring element affects the number of pixels being added or removed from the object in the image.
The most basic morphological operations used are dilation and erosion.

Erosion: Erosion removes pixels on the object boundaries in the image by changing it to the background pixel. This shrinks the object and breaks up a single object.

Dilation: Dilation, on the other hand, adds pixels to the object boundaries by changing the background pixel surrounding it. This enlarges the object and multiple objects could merge together as one.
Opening or closing is a single function with the combination of dilation and erosion.

Opening: In opening, the image would undergo erosion followed by dilation. This removes the small object pixels before enlarging the remaining.

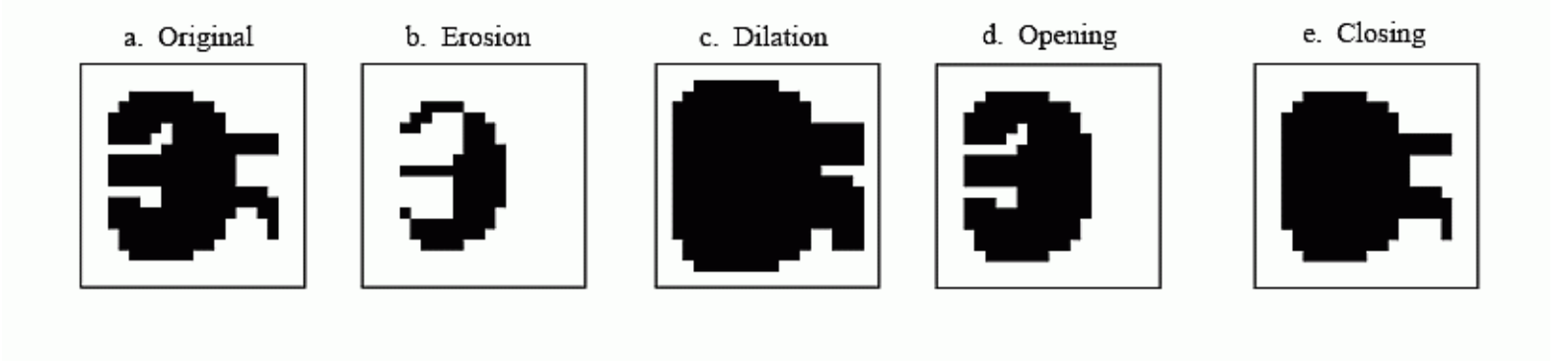


Figure 7: Example of Morphological operations

Closing: In Closing, the image would undergo dilation followed by erosion. This removes the small background pixels before enlarging the remaining. In this way, the contours of the object smoothen and small object gaps fused. These functions help to handle noise in the image or adjust it to "enclose" a certain desired object.

Segmentation: Image segmentation is used to locate the objects or boundaries in the image. In edge detection function, the contours of the objects are extracted from the image. Canny method is used for this project as it is better compared to the other similar Matlab functions by having two different thresholds to detect the edges. .

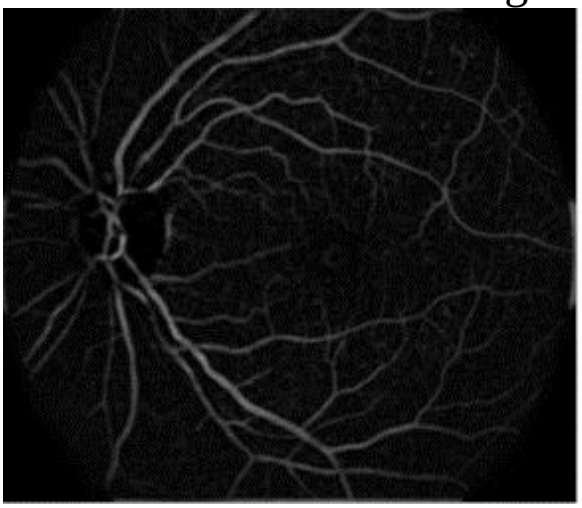


Figure 8:a.Input image

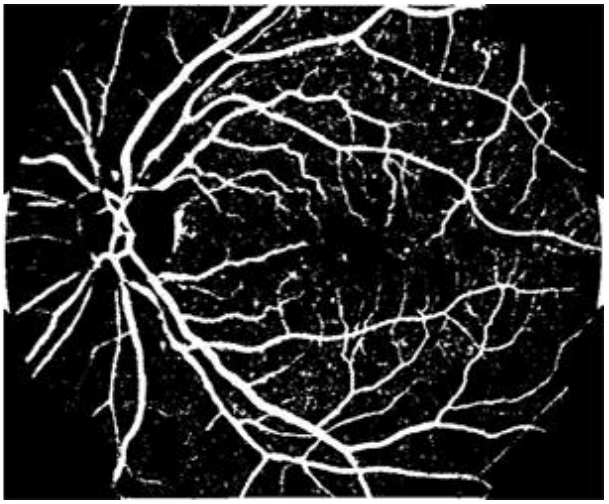


Figure 8:b.Output Image after Segmentation

BLOOD VESSEL DETECTION

Blood vessels are extracted in this project for the identification of diabetic retinopathy. The contrast of the fundus image tends to be bright in the center and diminish at the side, hence preprocessing is essential to minimize this effect and have a more uniform image. After which, the green channel of the image is applied with morphological image processing to remove the optical disk. Image segmentation is then performed to adjust the contrast intensity and small pixels considered to be noise are removed. Another green channel image is processed with image segmentation and combined with the mask layer. These two images are compared and the differences are removed. The obtained image would represent the blood vessels of the original image.

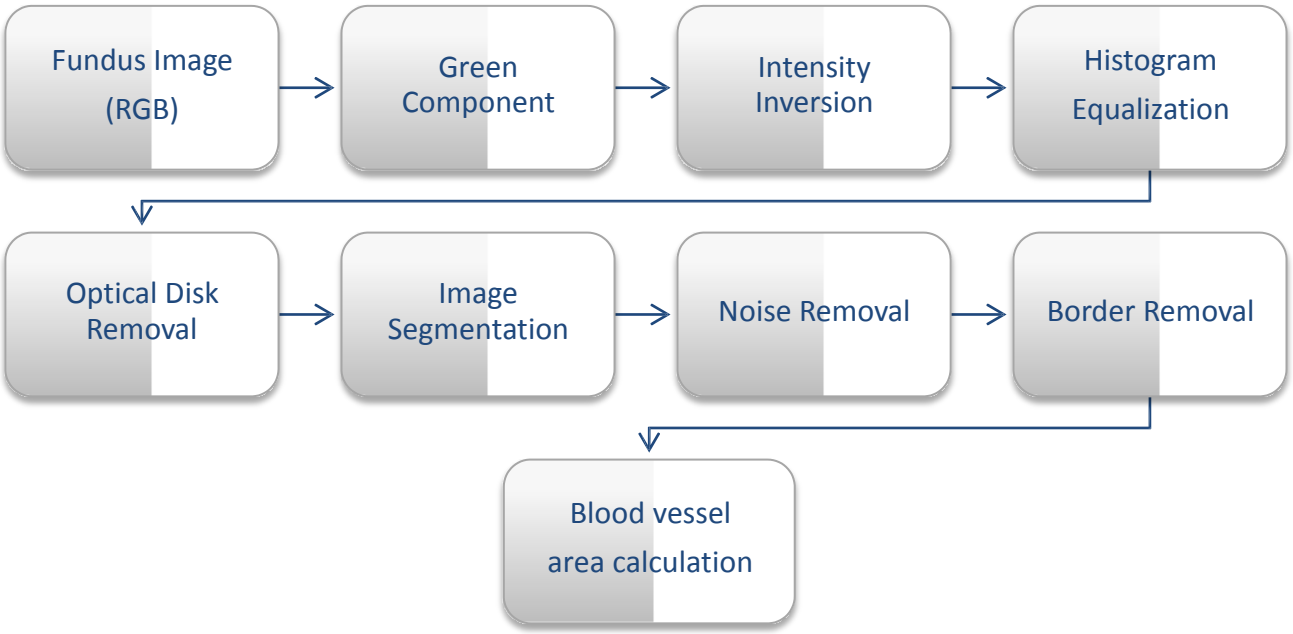


Figure 9: Block Diagram of Blood Vessel Detection

Step1: Fundus Image acquisition:

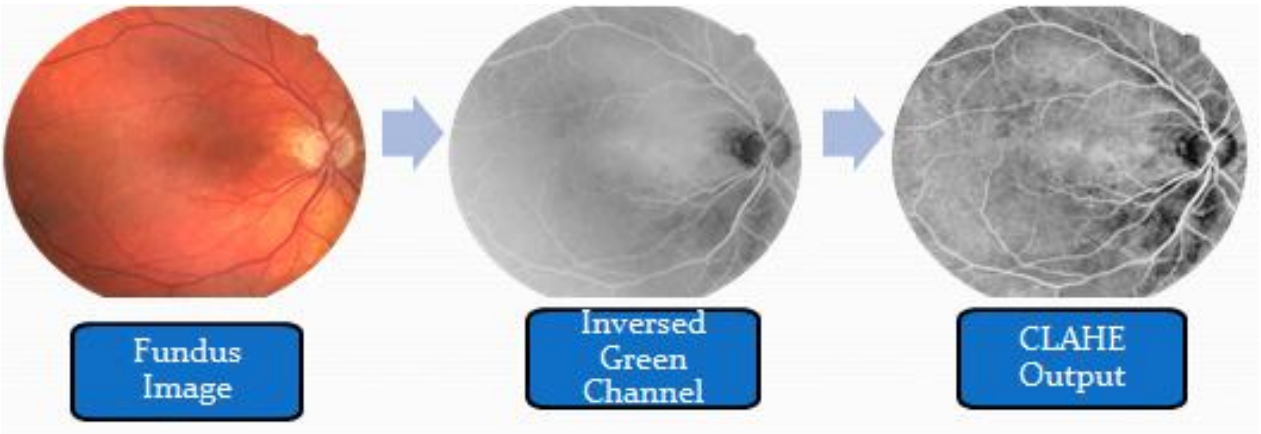
Originally retinal images are obtained using fundus camera by ophthalmologists by Fundus Camera. We have used DRIVE Database for Fundus Image testing purpose.

Step2: Intensity Inversion of Green Channel:

The intensity of the green channel is then inversed before adaptive histogram equalization is applied. Gray scale image instead of the green channel is used as it is more efficient in the detection in later stages.

Step3: Histogram Equalization:

The contrast of the fundus image tends to be bright in the center and diminish at the side, hence preprocessing is essential to minimize this effect and have a more uniform image. Hence, the image's contrast is stretched by applying adaptive histogram equalization.



Step4:Optical Disk Removal:

The optical disk is a black patch in the image as shown at Figure 11.d. Morphological opening which consisted of erode followed by dilate is applied. Erode function protects the small blood vessels by reducing their sizes while dilate function blows up the larger remaining details which are intended to be removed. The optical disk is then removed by subtracting Figure11 with Figure: 10.d.

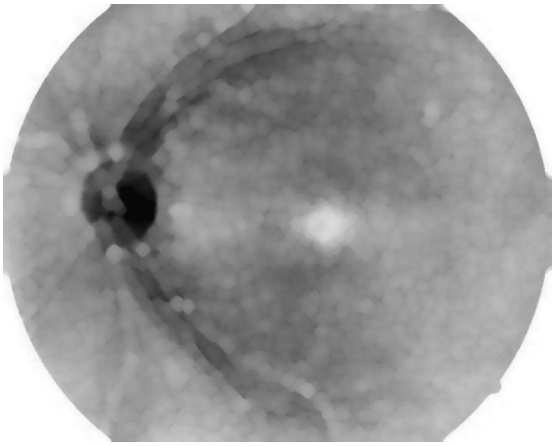
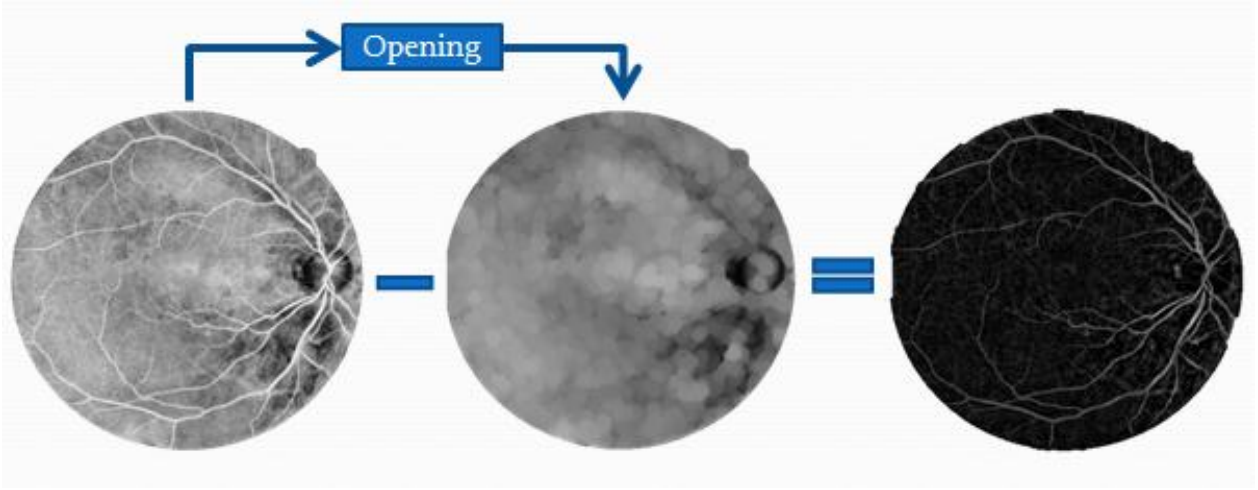
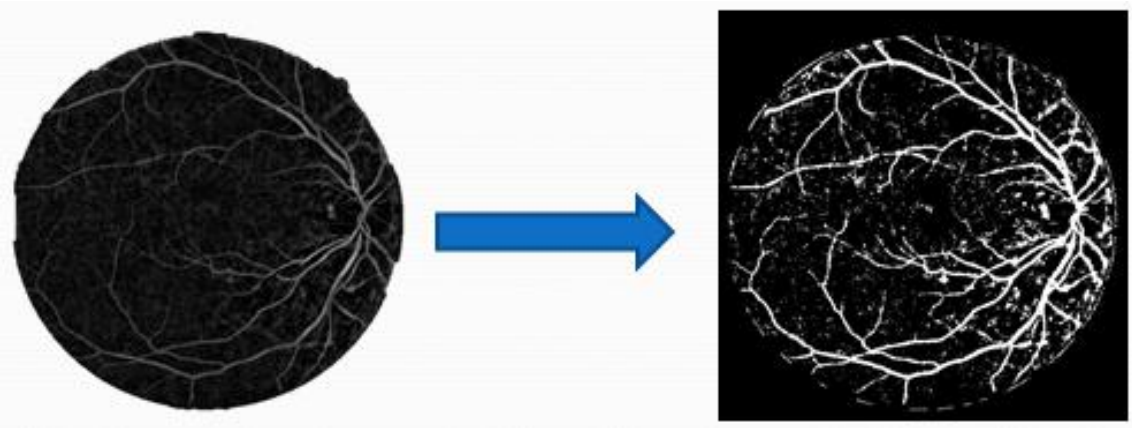


Figure 11: Image after Opening



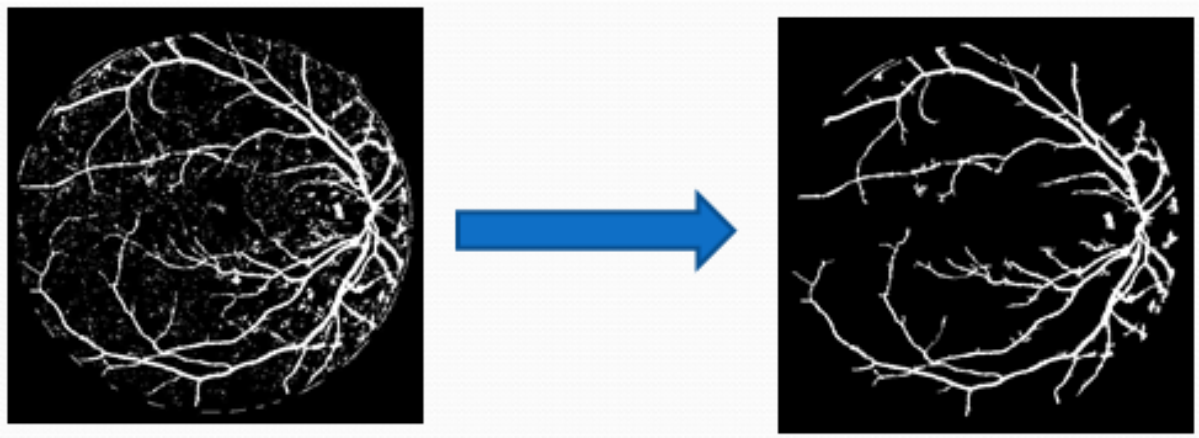
Step 5: Image segmentation:

We used binary thresholding method for image segmentation step. For this, the image (Figure:11.e) is then converted to a binary image. The pixels of the input image are converted to binary 1 (white) for values greater than the selected threshold and to binary 0 (black) if otherwise.



Step 6: Noise Removal:

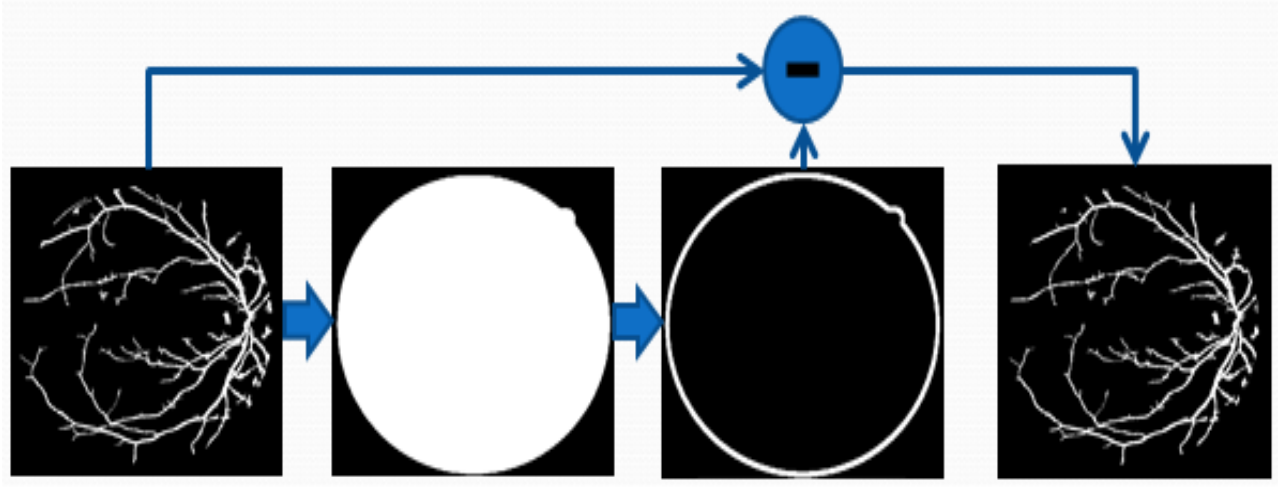
After segmentation, the binary image becomes noisy. So, we calculate all connected clusters & delete pixel-areas smaller than a particular value, considering them as noise.



Step 7: Border Removal:

While working with binary image, the circular border creates some noise pixels. Gray scale image instead of the green channel is used as it is more efficient in border detection. We used canny method to detect the edges before enclosing the circular region with a top and bottom bar. Image filling is done to fill the region. The circular border is obtained after subtracting the dilated image with the eroded image. The

border is then subtracted from Figure 11:g to get final image Figure 11:h.



Step 8: Blood vessel area calculation:

Finally the area of the blood vessels is obtained by using two loops to count the number of pixels with binary 1 (white) in the final blood vessel image(Figure 11:h)

Stages of blood vessel detection

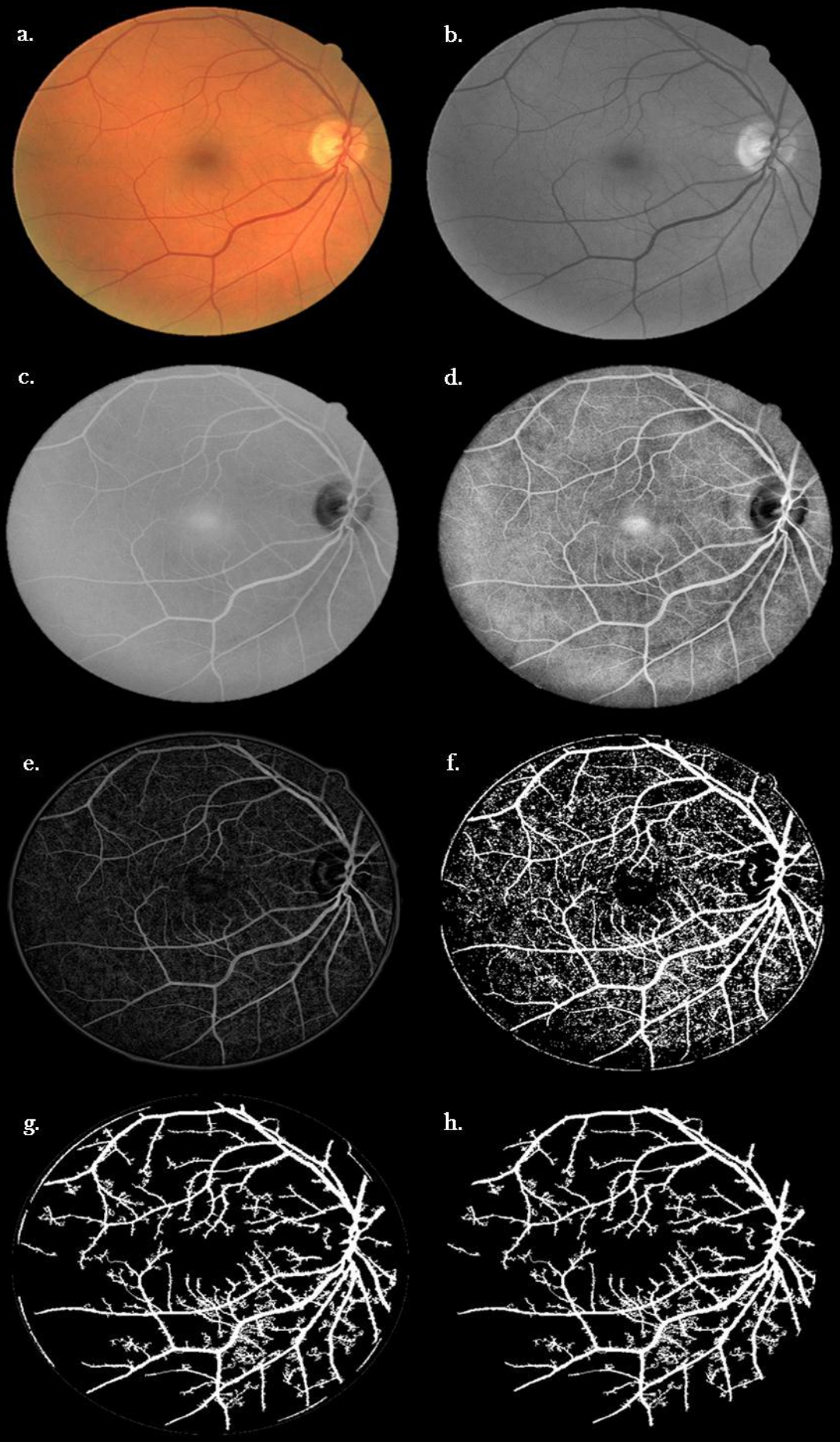
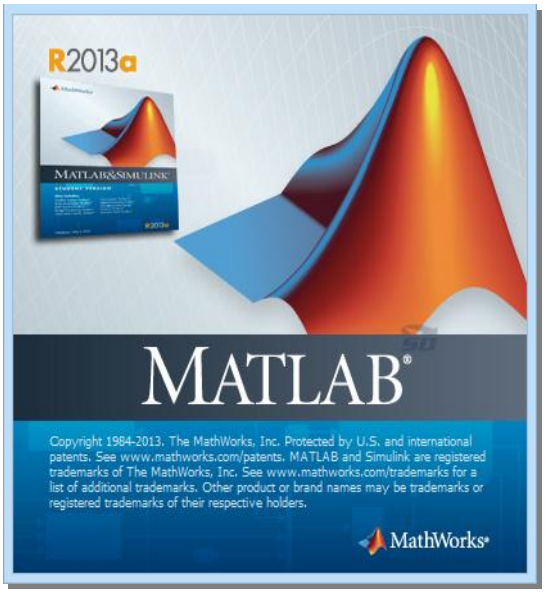


Figure 10: a.Original Image ; b. Green component ; c. Intensity Inversion ; d.Histogram Equalization ; e. Optical Disk Removal ; f. Image Segmentation ; g. Noise Removal ; h. Border Removal

SOFTWARE IMPLEMENTION

Software implementation of Blood vessel detection & area calculation in our project is done in three different phase.

Initially we implemented the basic pre-processing stages by matlab programming on MATLAB vR2013a. MATLAB is chosen for development phase software implementation as some of the basic functions are already available in Matlab Image Processing Toolbox.



MATLAB (**mat**rix **lab**oratory) is a multi-paradigm numerical computing environment and fourth-generation programming language. Developed by MathWorks, MATLAB allows matrix manipulations, plotting of functions and data, implementation ofalgorithms, creation of user interfaces, and interfacing with programs written in other languages, including C, C++, Java, and Fortran.

Although MATLAB is intended primarily for numerical computing, an optional toolbox uses the MuPAD symbolic engine, allowing access to symbolic computing capabilities. An additional package, Simulink, adds graphical multi-domain simulation and Model-Based Design for dynamic and embedded systems.

MATLAB PROGRAM

```
function [area_bloodvessels_final bloodvessels_final] = function_BV
(~)
%Blood Vessels
%Prepocessing of image
%=========================================0
I=imread('eye.jpg');
I2=imresize(I, [576 720]); %resize image to stdize
figure, imshow(I2), title('Fig. 1:Resized Image to 576X720');
GreenC=I2(:,:,2); %(row, column, 2-->green)
figure, imshow(GreenC), title('Fig. 2:Green Component Image');
%=========================================
%remove date (upper left corner)
for x=1:30
    for y=1:60
    GreenC(x,y)=0; %255=white, 0=black
    end
end
figure, imshow(GreenC), impixelinfo, title('Fig. 3:Patched Date');
%=========================================
Ginv2=imcomplement(GreenC); %black and white are reversed
figure, imshow(Ginv2), title('Fig. 4:Inversed image & Histgram');
Gadpt_his3=adapthisteq(Ginv2); %enhances the contrast of the
intensity image by transforming the values
% using contrast-limited adaptive histogram equalization (CLAHE),
histeq --> too dark
figure,imshow(Gadpt_his3), title('Fig. 5:Image & Histgram after
adaptive histeq');
subplot(4,1,4 ), imhist(Gadpt_his3)
%=========================================
%=========================================
%morphological gradient (blurry image depending on value)
%SE = strel('disk',R,N) %flat, radius, N - 0,4,6,8,default4
%SE = strel('ball',R,H,N) %nonflat, radius, height, N line-shaped
element,default8
%imerode - remove small details to avoid increasing their size
%imdilate - increase the size
%imopen - for imerode(decrease) then imdilate (increase)
%=========================================
%se = strel('disk',8); %histg is not smooth
se = strel('ball',8,8);
Gopen4=imopen(Gadpt_his3,se); %imerode then imdilate
figure, imshow(Gopen4), title('Fig. 6:Image after Imerode &
Imdilate');
G_Odisk_R5=Gadpt_his3-Gopen4; %removing the optical disk
%subtract the black part for the blood vessels
figure(2132), imshow(G_Odisk_R5), title('Fig. 7:Removed optical
disk')
%=========================================
```

•••••••••

```
%converting the fundus image (RGB) to grayscale
Grayscale_8 = rgb2gray (I2);
Grayscale_brighten_9 = imadjust(Grayscale_8);
figure, imshow(Grayscale_8), title('Fig. 10:Grayscale Image');
figure, imshow(Grayscale_brighten_9), title('Fig. 10A:Brighten
Grayscale Image');
%Find edges (outline) of the objects in the grayscale image
%Determine the manitude of the gradient of intensity that is larger
than threshold
%Have many other method, cany detect more and best to use
%0.01-0.05 too much, 0.08-0.1 ideal threshold, 0.20-0.25 lost too
much
outline_border=edge(Grayscale_brighten_9, 'canny', 0.09);
figure, imshow(outline_border), impixelinfo, title('Fig. 11:Edges
of the image');
%=========================================
%Drawing two lines to enclose the circular region as it would
affect the area calculation later
%image size is 576:720
for x=2:5
    for y=100:620 %for top bar 4x520
    outline_border(x,y)=1; %1->white
    end
end
for x=572:575
    for y=100:620 %for bottom bar 4x520
    outline_border(x,y)=1; %1->white
    end
end
figure, imshow(outline_border), impixelinfo, title('Fig. 11A:Image
with 2bars');
%=========================================
%BW2 = imfill(BW,'holes') fills holes in the binary image BW.
%A hole is a set of background pixels that cannot be reached by
%filling in the background from the edge of the image
Grayscale_imfill_10 = imfill(outline_border, 'holes');
figure, imshow(Grayscale_imfill_10), title('Fig. 12:Imfill on the
image');
%structuring element, can only use disk and not ball as
%ball is nonflat and imerode cant perform dilate to a binary image
with it
se = strel('disk',6);
%cant use imopen in this case to replace imerode & imdilate
Grayscale_imerode = imerode(Grayscale_imfill_10, se); %reduce size
Grayscale_imdilate= imdilate(Grayscale_imfill_10, se); %increase
size
figure, imshow(Grayscale_imerode), title('Fig. 12A:Imerode');
figure, imshow(Grayscale_imdilate), title('Fig. 12B:Imdilate');
%determining the circular border of the image
Grayscale_C_border = Grayscale_imdilate - Grayscale_imerode;
```

```
Grayscale_C_border_L = logical(Grayscale_C_border); %Convert
numeric values to logical
figure, imshow(Grayscale_C_border_L), title('Fig. 12C:Circular
border');
%Area Calculation for Grayscale_C_border_L
area_Cborder = 0;
for x = 1:576
    for y = 1:720
        if Grayscale_C_border_L(x,y) == 1
        area_Cborder = area_Cborder+1;
        end
    end
end
%area_Cborder
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%================================================================
```

•••••••••

```
%% Getting the image with blood vessels
%% finetune_blood --> Blood vessels with lesser noise after AND
function
%% box_5pixel --> 4 side with 5 white pixels each
%% Grayscale_C_border_L --> the circular border of the image
figure, imshow( box_5pixel + Grayscale_C_border_L ), title('Fig.
19:Subtracting Image');
bloodvessels_final = finetune_blood - box_5pixel -
Grayscale_C_border_L; %remove the borders
figure, imshow(bloodvessels_final), title('Fig. 20:Final Blood
Vessels image');
%caluating the area of blood vessels
area_bloodvessels_final = 0;
for x = 1:576
    for y = 1:720
        if bloodvessels_final(x,y) == 1
            area_bloodvessels_final = area_bloodvessels_final+1;
        end
   end
 end
%area_bloodvessels_final
```

MATLAB OUTPUT SCREEN SHOTS

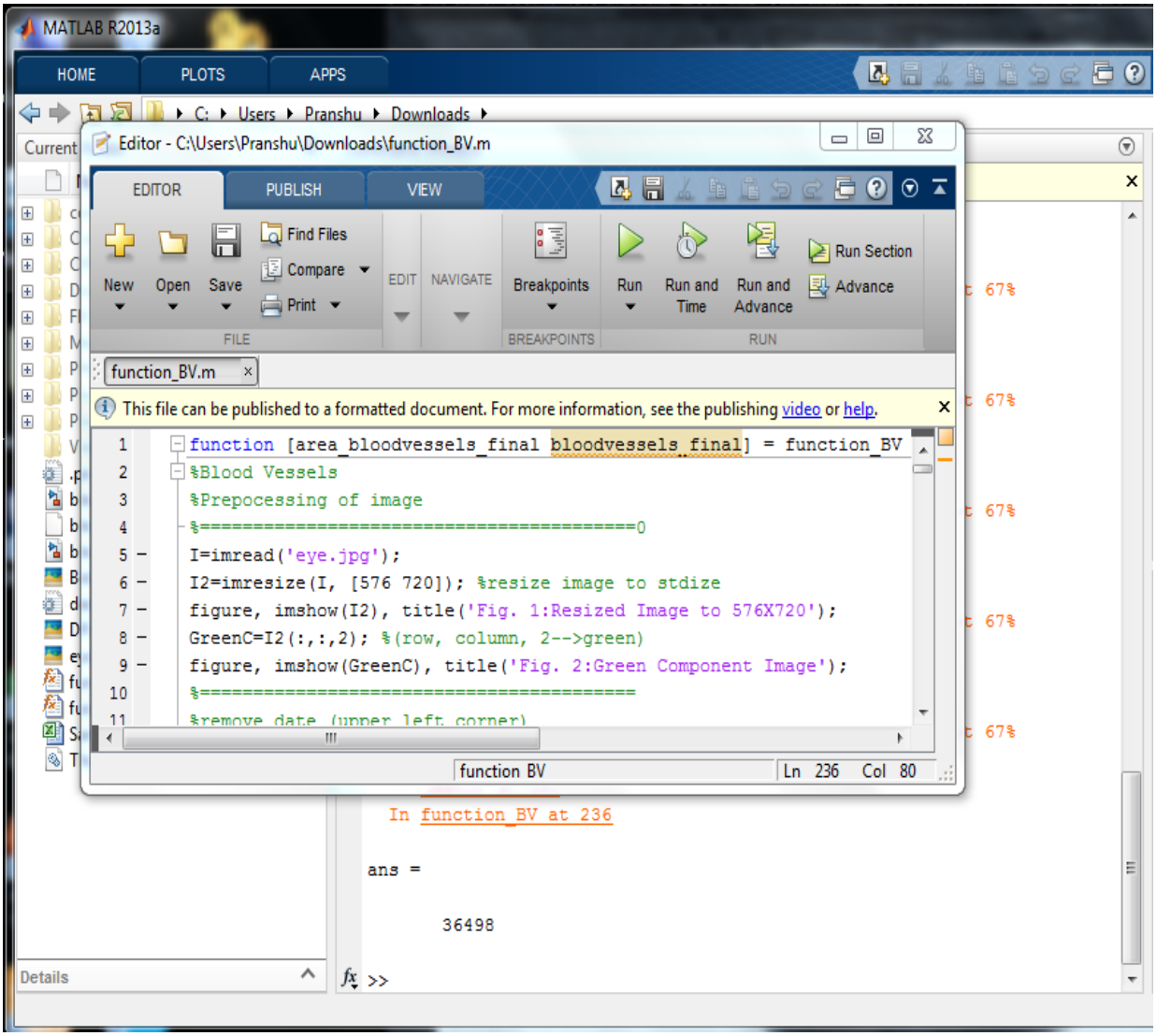


Figure 12 : MATLAB IMPLEMENTATION with output (blood vessel area).

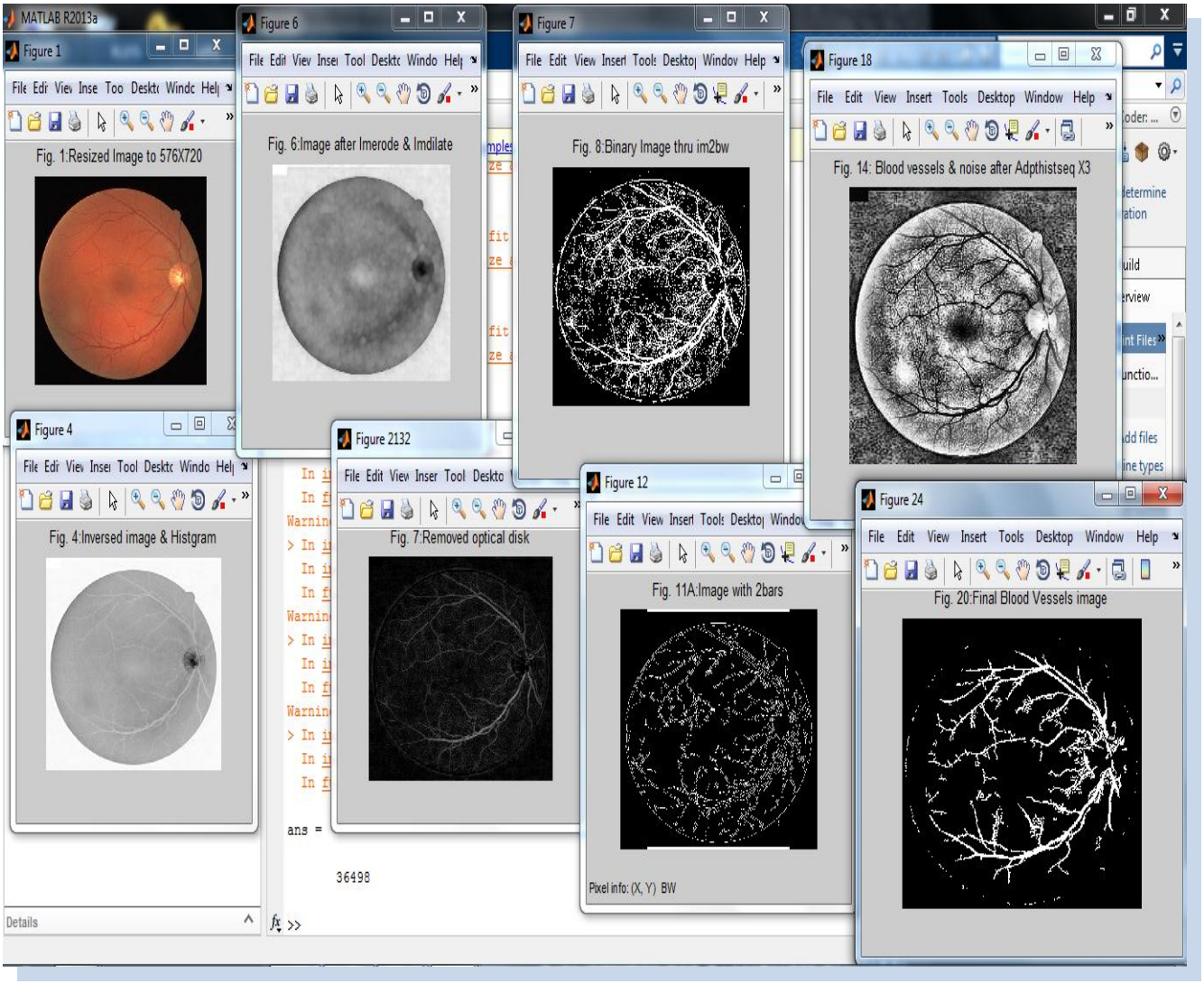


Figure 13: MATLAB IMPLEMENTATION with images of processing step

RESULTS AND DISCUSSION

FUNDAS IMAGE NO	BLOOD VESSEL AREA	DR STAGE	FUNDAS IMAGE NO	BLOOD VESSEL AREA	DR STAGE
Image-1	24807	Mild NPDR	Image-11	23740	Mild NPDR
Image-2	24467	Mild NPDR	Image-12	19467	Normal Eye
Image-3	19491	Normal Eye	Image-13	21006	Normal Eye
Image-4	21144	Normal Eye	Image-14	21586	Normal Eye
Image-5	16954	Normal Eye	Image-15	22519	Mild NPDR
Image-6	25004	Mild NPDR	Image-16	21057	Normal Eye
Image-7	19707	Normal Eye	Image-17	28412	Moderate NPDR
Image-8	14787	Normal Eye	Image-18	35611	Moderate NPDR
Image-9	13753	Normal Eye	Image-19	22867	Mild NPDR
Image-10	17555	Normal Eye	Image-20	51182	PDR

We take 20 images of eye which is basic fundus image from a website. In which some eye images are affected from different types of DR and some are normal eye images. So we take the images as an input into our program and get the output as a no. of pixels in blood vessel area. So by knowing the types of DR of the images previously we can easily understand the corresponding Blood vessel area for those types of DR. So, next time when we take an eye images to detect whether it is affected from DR or not, we can easily say it by seeing the no. of blood vessel area.

CONCLUSION

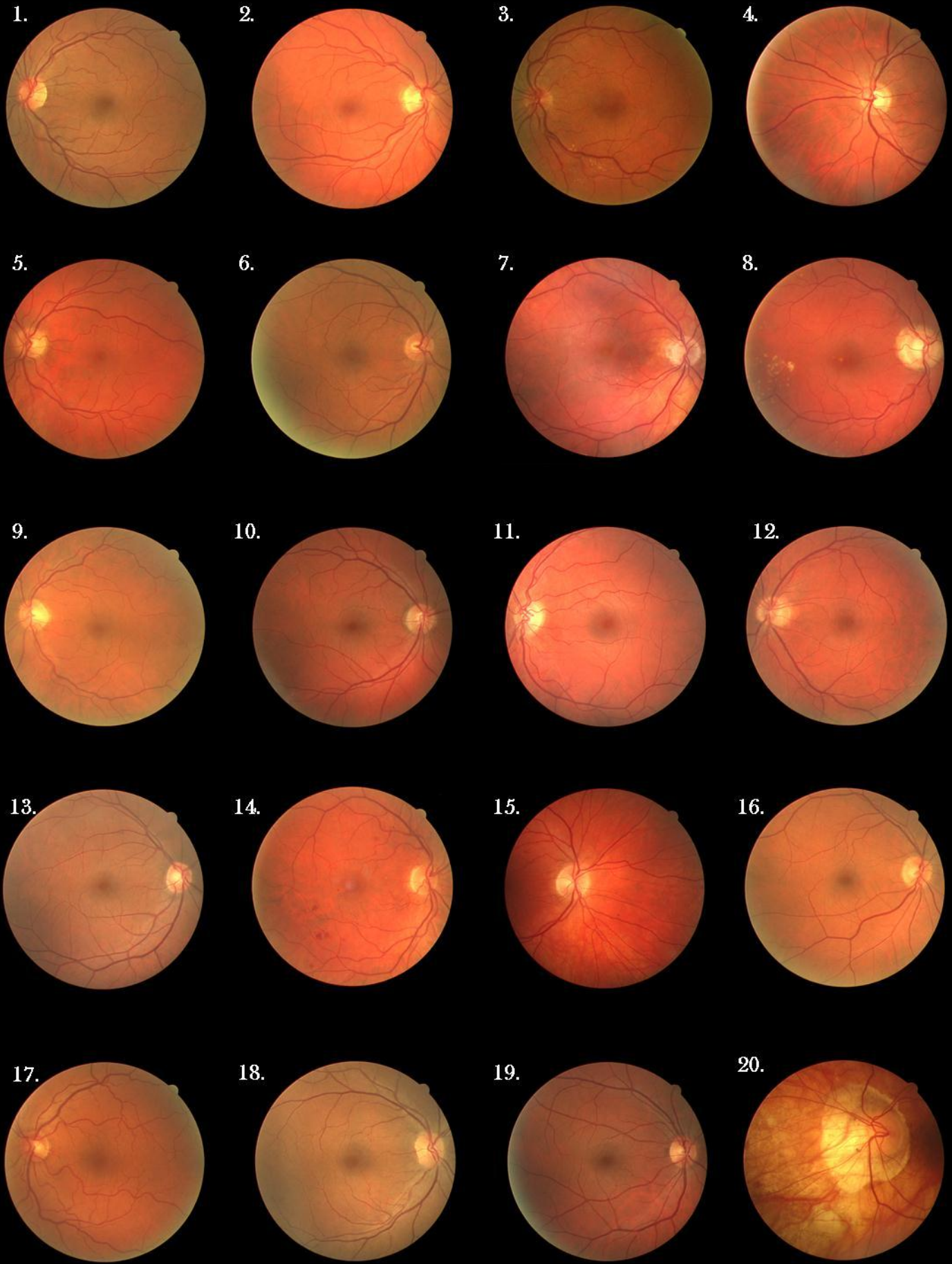
The primary objective of the work is to develop a hardware based system that will be able to identify patients with Diabetic Retinopathy either from color or gray level fundus image.

In the first phase of the work we have mainly highlighted the software based approach with some earlier renowned work on same field and observe that for large scale diagnosis we need to develop a hardware based approach for the ease of detection.

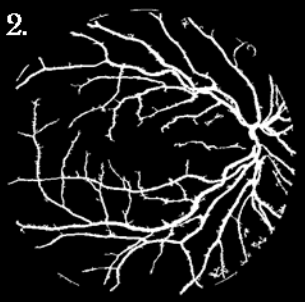
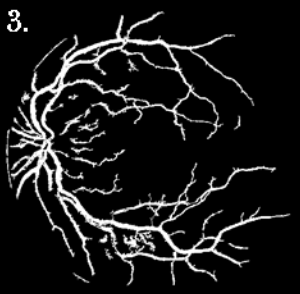
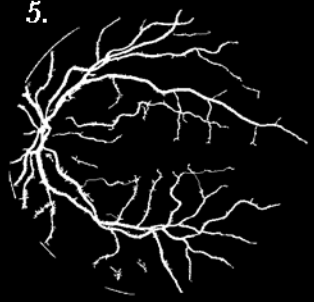
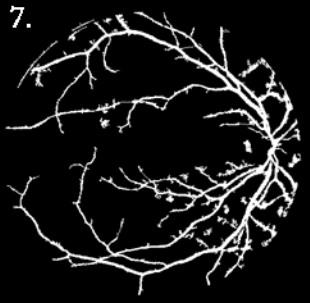
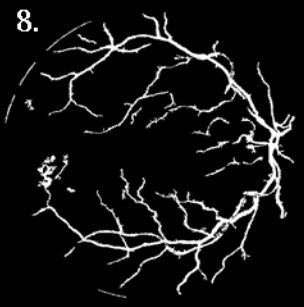
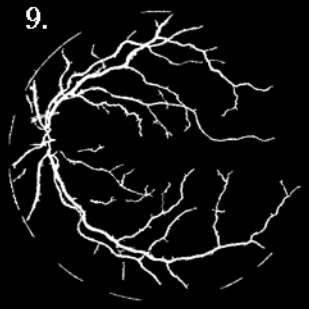
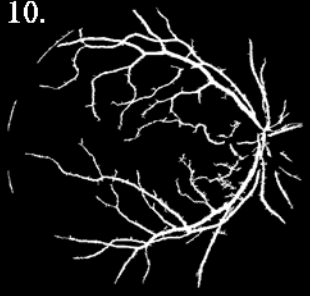
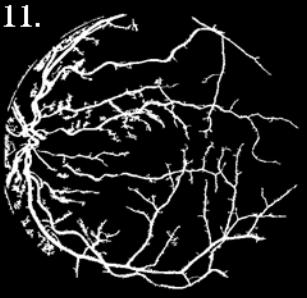
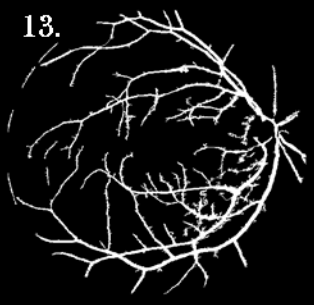
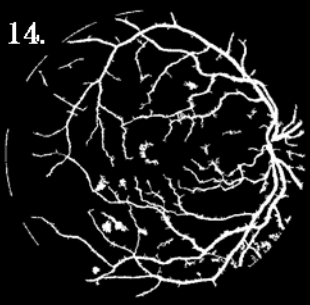
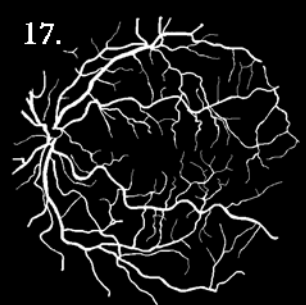
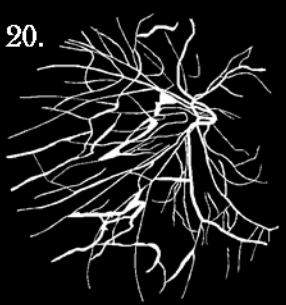
So, in the second phase of our work we are mainly concentrated in the hardware based system. So we have done our project up to a software implementation stage which will be successfully followed by hardware based system requirements. Though more work is still required to be done in terms of hardware detection and to reduce the error due to over enhancement of noise and misdetection in this work.

The achievements of this work include very good result in the diagnosis process and it shows how far the use of image processing can replace the tedious and strenuous work at our various hospitals. The results itself reflects the effectiveness of the hardware based implementation technique.

Annexture I: DRIVE Image Database



Annexture 2: Detected Blood vessel Images

1. 
2. 
3. 
4. 
5. 
6. 
7. 
8. 
9. 
10. 
11. 
12. 
13. 
14. 
15. 
16. 
17. 
18. 
19. 
20. 

REFFERENCE

[1]Banerjee,R. et al .'Hardware Based Analysis On Automated Early Detection Of Diabetic Retinopathy',2nd International Conference On Computer, Communication, Control And Information Technology

[2] Banumathi A, Karthika, R., Kumar.A, "Performance analysis of matched filter techniques for automated detection of blood vessels in retinal images", Conference on Convergent Technologies for Asia Pacific Region (2003), 2, pp 543–546.

[3] Iqbal,M.I. et al, "Automatic Diagnosis Of Diabetic Retinopathy Using Fundus Images": By Blekinge Institute Of Technology Referenced October 2006.

[4] Vallabha, D., Dorairaj,et al. "Automated Detection and Classification of Vascular Abnormalities in Diabetic Retinopathy", 38th Asilomar Conference on Signals, Systems and Computers, November 2004.

[5] Wong Li Yun , U. Rajendra Acharya, Y.V. Venkatesh , Caroline Cheec,Lim Choo Min, "Identification of different stages of diabetic retinopathy using retinal optical images", E.Y.K. Ng / Information Sciences(2008) 178 , pp 106–121.

[6] Gonzalez, Rafael C. and Woods, Richard E. 'Digital Image Processing using MATLAB', 2nd edition. Prentice Hall, 2002. ISBN 0-201-18075

[7] IMAGE DATABASE USED :- http://www.isi.uu.nl/Research/Databases/DRIVE/commence_download.php

[8] www.mathworks.com/products/image/functionlist.html