Diabetic Retinopathy – Feature Extraction and Classification using Adaptive Super Pixel Algorithm

Balambigai Subramanian, V. Saravanan, Rudra Kalyan Nayak, T. Gunasekaran, S. Hariprasath

***Abstract:** Diabetic Retinopathy is an ocular manifestation of diabetes . The longer a person has diabetes, higher are the chances of having diabetic retinopathy in their visual system. Hence the objective of this research work is to propose an automated, suitable and sophisticated approach using image processing so that diabetic retinopathy can be detected at early levels easily and damage to retina can be minimized. A vital point of diabetic retinopathy that it causes detectable changes in the blood vessels of the retina. The focal blurred edges are detected so as to dismiss the false alarms. A two-level approach is used here to classify data. Firstly, optimal features are extracted from the training data and secondly, the classification is done by the use of the adaptive super pixel algorithm and then the test data is analyzed. Adaptive super pixel algorithm can adjust the weights of various features based on their discriminating ability. After the application of algorithm, the diabetic eye is detected by means of various parameters like colour, texture, spatial distance, contour, mean, standard deviation, entropy and maximum pixel points. This research can aid the doctor for easy detection of the disease as it given an accuracy of about 98.33%.*

***Keywords:** Retinopathy, fundus, adaptive super pixel, classification*

I. INTRODUCTION

Diabetes occurs among various people due to various factors like sedentary life style , stress and eating habits. Diabetic Retinopathy usually happens if a person has diabetes for more than ten years or more. Diabetic Retinopathy (DR), causes around five percent of blindness among people and this is one of the major reason that causes blindness among diabetics. According to World health Organization (WHO) estimation, 425 million of world population is having the diabetes [1] .Research indicates that progress of the reduction of can be reduced or eradicated if diabetic retinopathy is found at an early stage. It is found that large number of people having diabetic retinopathy are being tested for this disease by manual method by trained opthamalogists which is a time consuming process and sometimes delay in diagnosis may lead to delay in treatment to patients.

Diabetes is usually caused when insulin is produced less in body or if the human body develops resistance to glucose or when both the causes occur simulataneously[2].A person with diabetes has a condition in which the quantity of glucose in the blood is too elevated (hyperglycemia). This is because the body does not produce enough insulin, produces no insulin, or has cells that do not respond properly to the insulin the pancreas produces[3]. Research says for about 90% of diabetics, eye disease can be managed through better medical treatment and periodic checkup of the eyes. Image processing is used by the ophthalmologists to diagnose the various eye diseases . In India, it is predicted that 79.4 million people may suffer from diabetes, out of which about 75 percent of people those who have this disease for more than 20 years may have certain form of problem in vision due to diabetic retinopathy[4] . The blood vessel changes in the retina of the eye gives information about change in the values of some of the features of the eye, such as blood vessels of the eyes , optic disc (OD), that are helpful to find the occurrence of diabetic retinopathy (DR) or any other eye diseases.

Poor people are easily affected by diabetic retinopathy due to the non availability of screening , early diagnosis and treatment. Many screening tools are available to diagnose diabetic retinopathy. Fundus cameras capture digital image of the blood vessels in the retina and sometimes they may be having excessibe brightness etc that reduce the quality of the image. Hence, there is a need to enhance the images by the use of image enhancement. Features of the eye that help to detect the retinopathy are blood vessels, textures microaneurysms , exudes etc. These features increase in size and may destruct the capillaries causing blood leakage in the eye leading to blindness.. Hence, the objective of this research is to detect diabetic retinopathy earlier to minimize the damage to retina[5].

II. LITERATURE REVIEW

Ronakorn Panjaphongse (2017) used the morphological operators along with support vector machine (SVM) to screen diabetic retinopathy earlier among the diabetics. Initially, pre processing of the image is done to improve image quality,followed by filtering after edge detection and morphological operations. The extracted features are given as input to the support vector machine classifier which differentiates between healthy

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and diabetic retinopathy affected eye images. The proposed method iwas verified on three datasets and this method gave an accuracy of 90% . The grading of severity was based on the values of the various above mentioned parameters for the detected lesions [6].

Manoj Kakarla (2016) discussed about extracting the various features of the eye in an optimal manner, followed by feature extraction and classification of diabetes using naïve bayes classifier. This work discusses an expert system to identify the stage of diabetes based on patients test result. Before performing classification process, optimal features are extracted based on data sets for the purpose of reducing time complexity over the classification process[7]. Then the classification process is performed by naïve bayes theorem to identify each patient's stage in the progress of the disease diabetes. By implementing these concepts, the efficiency of classification increases and also reduces the time complexity for performing the classification process.

K. R. Ananthapadmanaban etal (2014) proposed the chance of occurrence of diabetic retinopathy based on classification using data mining methods[8]. In this work, diabetic retinopathy has been diagnosed earlier. The preprocessing operation improves quality of the image by reducing the effects of excessive brightness. In the second step, the optic disc has to be located and extracted from the retinal image. The third step consists of the segmentation to find the exudates . In the last step, the neural network is used for feature extraction. The final results were compared with the opinion gathered from an eye doctor and it was found that the specificity was 95% and sensitivity was 96.65%.

Hilary W. Thompson (2016) proposed a novel method based on hierarchical decomposition and post filtering of edges to detect blood vessels to detect the occurrence of diabetic retinopathy at an early stage. This algorithm reduced the false decisions and was quite faster than conventional methods and needed less storage requirements[9].Ms. Bhaminee R Shetty (2017) proposed the automatic segmentation of microaneurysm using attribute filtering to reduce noise and thereby detected the exudates.Later, the feature of exudates was extracted from green channel of the RGB retinal image which was later given as input to the classifier. Statistical parameters such as mean, standard deviation, kurtosis etc were considered for classification and SVM gave sensitivity of 96.9%.[10]

III. EXISTING SYSTEM

3.1 NAÏVE BAYESIAN CLASSIFIER

This method extracts the optimal features initially from the training data [19]. Later, the values of positive and negative probability is found .Later, a new dataset of same size is created to which the values of previous data set are forwarded to help in the classification process. After completion of optimal feature extraction process, that dataset is taken and sent to classification. By applying classification algorithm, each patient's stage over the diabetes can be identified. The probability formula for naïve bayes algorithm is shown in equation 3.1

$$P(T/E) = \frac{P(E/T)\times P(T)}{P(E/T)\times P(T)+P(E/-T\times P(-T))} \quad \text{……... (3.1)}$$

3.2 SUPPORT VECTOR MACHINE

Support Vector Machine used points in space to represent the features so that the data can be mapped into different categories with clear boundary gap between them [14]. SVM is more suitable to analyze the fundus retinal image and to classify them into various classes such as normal or non-proliferative diabetic retinopathy or proliferative diabetic retinopathy. Using SVM classifier that uses a non linear kernel function, the accuracy level increases due to the techniques used for extraction and classification.

3.3 K-NN CLASSIFIER

K-Nearest Neighbour (KNN) algorithm classifies an object to an appropriate class based on the K value. Generally, K value is considered to be one for classification of retinal image. The graphs indicate the "variation" between the statistical parameters, which is the base for a K-NN classifier system to find out nearest neighbour for a new image [20]. This variation is found better for the statistical parameters extracted by using K-means classifier and this is best suited for classifying a retinal image as healthy or abnormal.

IV. PROPOSED SYSTEM

4.1 PROPOSED METHODOLOGY

In this proposed work, the input images of size 256x256 pixels are pre-processed to convert the input colour images in RGB to gray images because inherent complexity of gray image is less than the colour images. Also, gray scale reduces the complexity to one dimension from three dimension. RGB segmentation is used for dividing image into several region with their own characteristics for extracting useful target like lines and curves of an image. Image enhancement allows to brighten an image and makes it easier to identify the key features in preprocessing. The block diagram which is used for this research is shown in figure 4.1.

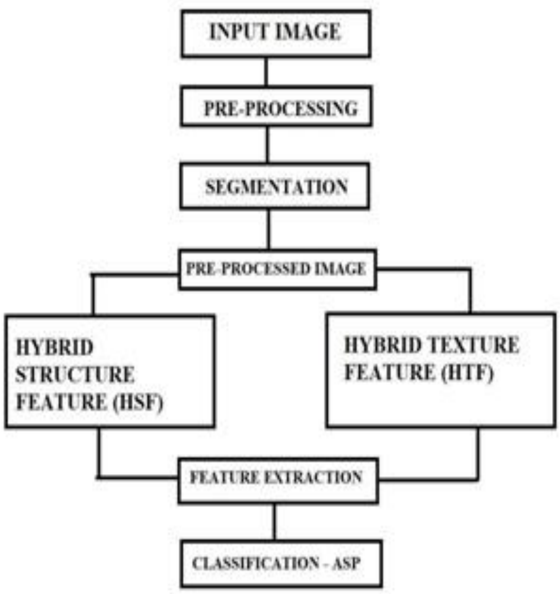

Figure 4.1 Block diagram of proposed system

Segmentation of preprocessed images is done by using DWT (Discrete Wavelet Transform) using Haar family wavelets. The preprocessed image is classified into two types based on their nature by Hybrid Structure Feature (HSF) and Hybrid Texture Feature (HTF). The HSF performs optical disc removal, threshold point calculation. And to find the region of interest. HTF involves in blood vessel removal and dots part detection.In feature extraction the black points, white points, mean error, standard deviation, entropy and maximum pixel points are extracted.

4.2 ADAPTIVE SUPER PIXEL ALGORITHM

Super pixel segmentation uses super pixels that show clear entity for human eye.This algorithm leads to cost reduction as super pixels are used and processing of super pixels become easier. Boundary are clearly marked based on regularity of the super pixels .Design of adaptive super pixel algorithm is due to the following factors such as colour difference is not sufficient to produce meaningful entity in low contrast images and various colours have various values for its parameters of texture, colour, contour etc.

The flow chart of the above algorithm is shown in figure 4.2.

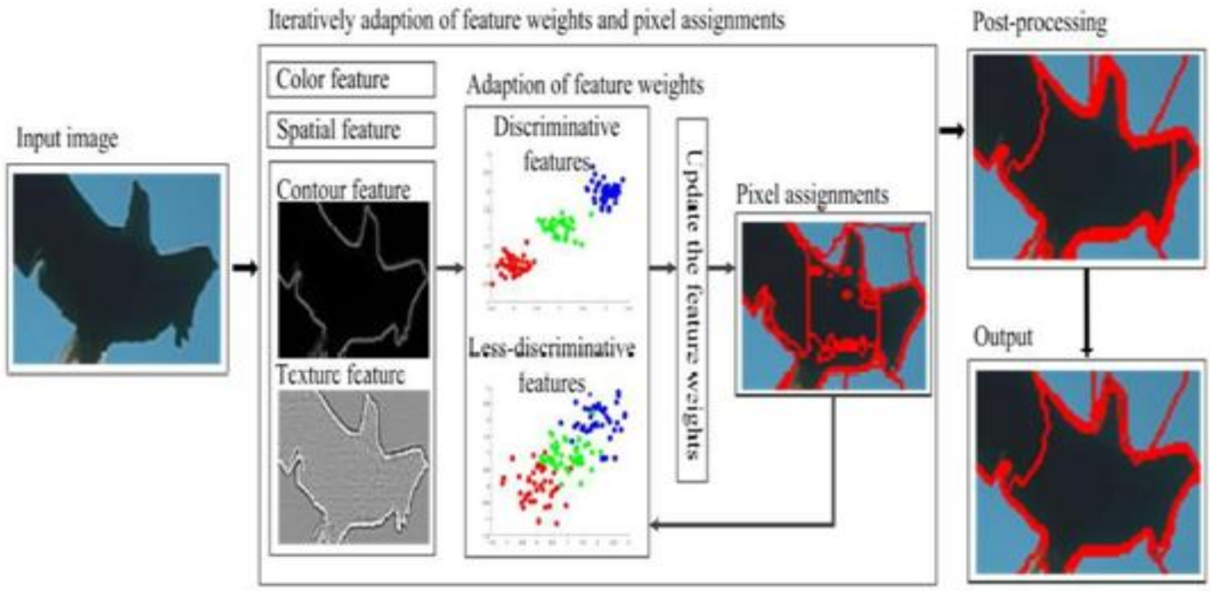

Figure 4.2 Flow chart of adaptive super pixel algorithm

The novelties of adaptive super pixel lie in:

- Consistency of Perception
- Adaptability of content
- Simplicity and efficiency

4.3 THE FEATURES AND DISTANCE MEASURE

Colour difference d_c: It is calculated using equation 4.1 as referred in [23]

$$d_c = \sqrt{\left(\frac{\Delta l}{k_l s_l}\right)^2 + \left(\frac{\Delta c}{k_c s_c}\right)^2 + \left(\frac{\Delta h}{k_h s_h}\right)^2}, \ldots\ldots\ldots\ldots (4.1)$$

where Δ *l*, Δ *c*, and Δ *h* represents the differences of *l*, c, and *h* between two pixels

- **Significance**: Colour difference is used to find the contrast of each pixels.

Spatial distance:

- **Significance:** Spatial distance is used to find the length of a straight line in a 3-D space i.e. the distance between the two-pixel points is calculated.

Image gradient:

- **Significance:** Image gradient is useful to find the changes in directional intensity of an retinal image .

Weber local descriptor:

- **Significance:** Weber local descriptor finds patterns and difference in texture to find the features.

Distance D between pixels is shown in equation 4.2.

$$D = \sqrt{\omega_c(d_c)^2 + \omega_s(d_s)^2 + \omega_g\left(d_g\right)^2 + \omega_u(d_u)^2}, \ldots.(4.2)$$

4.5 IMAGE SEGMENTATION

Image segmentation divides the image into many segments to simplify or change its representation so that its analysis becomes easier. Labels are assigned so that same label contains the pixels with similar characteristics. The steps involved are

i) Converting the RGB image to grayscale to retain luminance and remove hue and saturation.

ii) Improving the contrast by the method of histogram equalization.

iii) Next, image enhancement is done by contrast adjustment, morphological filtering so as to Return a modified version of the original retinal image.

iv) Optic disk present on the retina is very bright and it has to be extracted using feature extraction methods to identify the blood vessels.

v) Blood vessels are extracted to be examined for identifying various eye diseases such as diabetic retinopathy.

vi) The next step is the classification of exudates into hard or soft exudates which is done on the basis of threshold value.

vii) Mean, Median, Standard deviation are calculated and based on these features, the adaptive super pixel algorithm classifies the image of the eye as normal or diabetic eye.

V. RESULTS AND DISCUSSION

5.1. RESULTS AND DISCUSSION

Data Set Information:

Dataset used is Messidor image for this research work. All features represent either a detected lesion, a descriptive feature of an anatomical part or an image-level descriptor.

The data set comprises 60 images including 25 diabetic retinopathy images and 35 healthy retinal images of size 256 x 256 pixels.

The input image 11 of a normal eye is taken from above data set and is shown in figure 6.1 is taken for processing.

Figure 5.1 Normal eye

5.1.2 Enhanced Image

Image enhancement is accomplished by the use of filters, image editors and other tools to change the properties of retinal image of an eye.The enhanced image of normal eye is shown in figure 5.2.

Figure 5.2 Enhanced image normal eye

5.1.4 RGB Segmented Image

RGB segmentation is a process in which an image is divided into different regions in order to isolate the areas of interest on it.The RGB segmentation of normal eye is shown in figure 5.3.

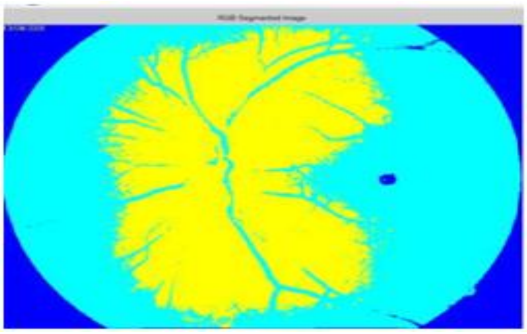

Figure 5.3 RGB segmentation of normal eye

5.1.5 Optic Disk Location

The optic disk location of normal eye is shown in figure 5.4

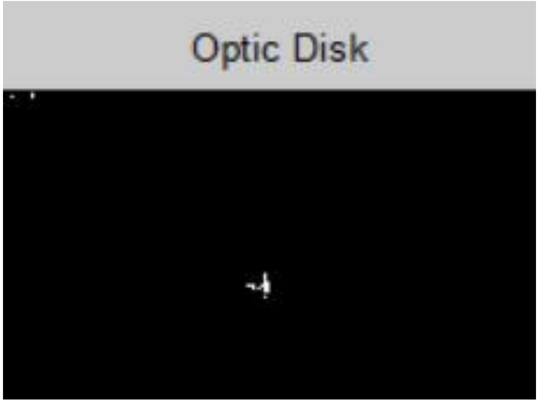

Figure 5.4 Optic disk location of normal eye

The white point represents the location of optic disk in the image.

5.1.6 Region of Interest

In region of interest the boundaries of defected lesions of eye may be defined on an image or in a volume, for the purpose of measuring its size. The region of interest for red, green and blue channel of normal eye is shown in figure 5.5

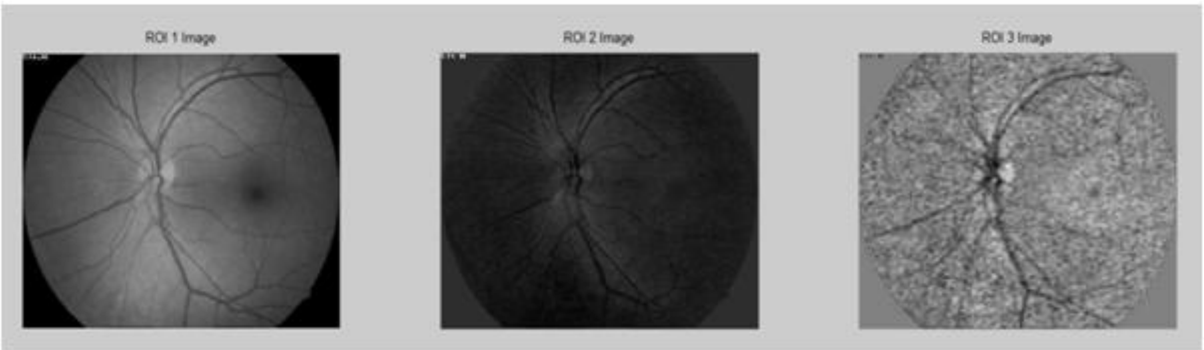

Figure 5.5 Region of interest of normal eye

The green channel is used for its good contrast when compared with red and blue channel.

5.1.7 Optic Disk Removal

The green channel is taken for further processing from region of interest .The optic disk removed image of normal eye is shown in figure 5.6

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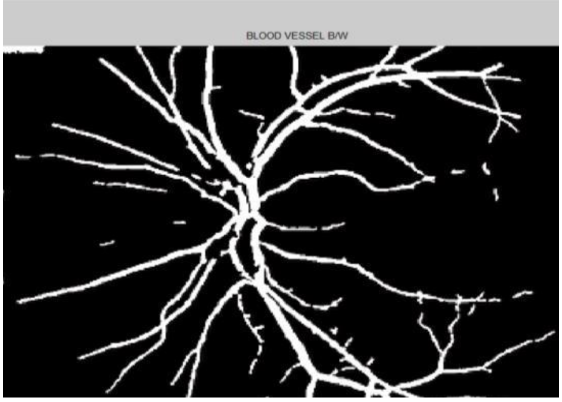

Figure 5.6 Optic disk removed image of normal eye

The optic disk is removed for better enhancement and classification

5.1.8 Blood Vessel Extraction

Blood vessel extraction is a processing step to extract vessels away from image to investigate the existence on some disease. The extracted blood vessel of normal eye is shown in figure 5.7.

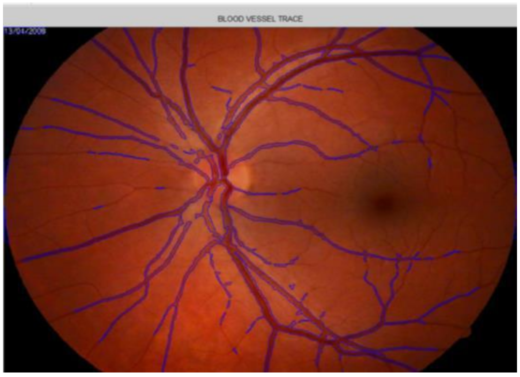

Figure 5.7 Blood vessel extracted image of normal eye

After optic disc removal the blood vessel trace is identified and removed for further classification

5.1.9 Dots Part

The white points and black points of normal eye is shown in figure 5.8. The occurrence of microaneurysm in eye is displayed as dots part.

Figure 5.8 Dots part of normal eye

Based on the number of white points the eye is classified as normal and affected.

5.1.10 Parameters measured

The parameters like mean, standard deviation, entropy and maximum pixel points of normal eye are shown in table 5.1.

Table 5.1 Parameters of normal eye (Image 1)

Image number	Deviation	Maximum pixel point	Entropy	Standard deviation	Affected pixel point	Normal pixel point
11	176.358	197.858	1.405	60.738	2.790	91422.30

5.2 RESULTS OF AFFECTED EYE

5.2.1 Input Image

An affected eye is shown in figure 5.9 is taken for processing.

Figure 5.9 Image of affected eye

5.2.2 Enhanced Image

The enhanced image of affected eye is shown in figure 5.10

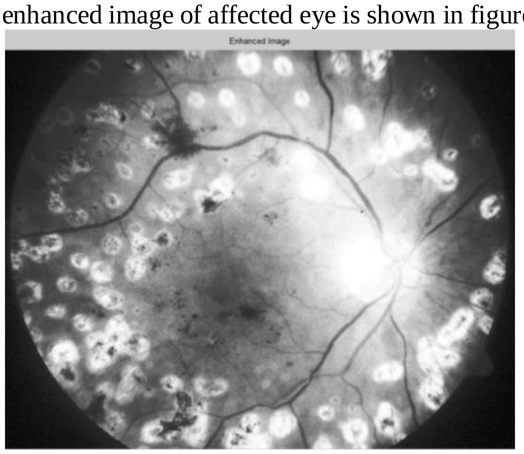

Figure 5.10 Enhanced image of affected eye

5.2.4 RGB Segmentation

The RGB segmentation of affected eye is shown in figure 5.11

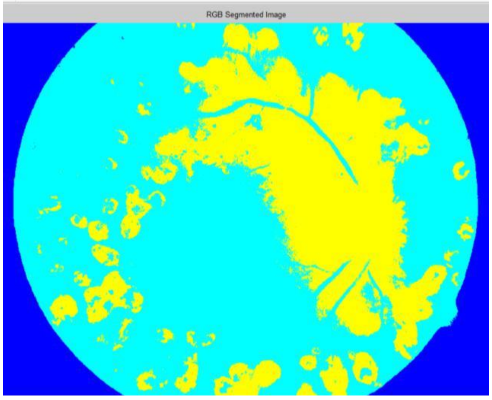

Figure 5.11 RGB segmentation of affected eye

The enhanced image is differentiated by RGB segmentation

5.2.5 Optic Disk Location

The optic disk location of affected eye is shown in figure 5.12.

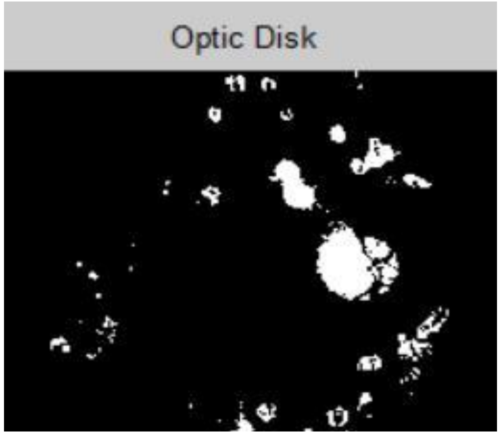

Figure 5.12 Optic disk location of affected eye

The white point represents the location of optic disk in the image.

5.2.6 Region Of Interest

The region of interest for red, green and blue channel of affected eye is shown in figure 5.13.

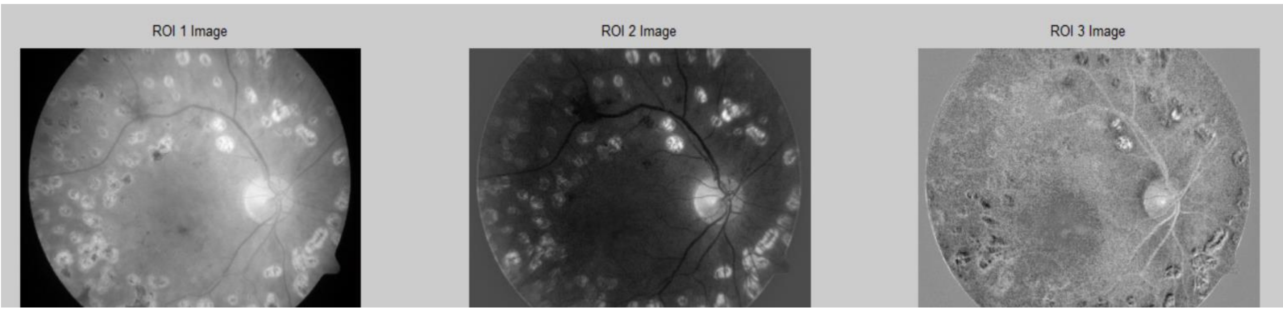

Figure 5.13 Region of interest of affected eye

The green channel is used for its good contrast when compared with red and blue channel.

5.2.7 Optic Disk Removal

The Optic disk removed image of affected eye is shown in figure 5.14.

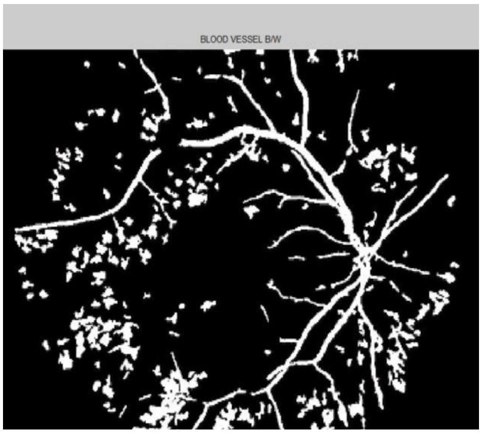

Figure 5.14 Optic disk removed image of affected eye

The green channel is taken for further processing from region of interest. The optic disk is removed for better enhancement and classification

5.2.8 Blood Vessel Extraction

The extracted blood vessel of affected eye is shown in figure 5.15.

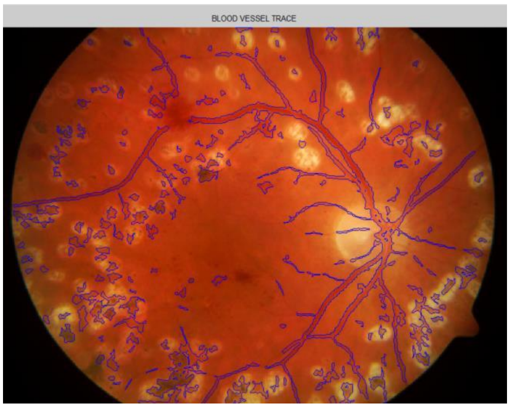

Figure 5.15 Blood vessel extracted image of affected eye

After optic disc removal the blood vessel trace is identified and removed for further classification

5.2.9 Dots Part

The white points and black points of affected eye is shown in figure 5.16

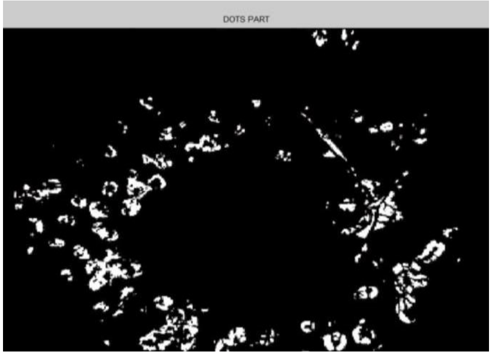

Figure 5.16 Dots part of affected eye

Based on the number of white points the eye is classified as normal and affected.

5.2.10 Parameters measured

The parameters of affected eye are shown in table 5.2.

Table 5.2 Parameters of affected eye (Image 045)

Image number	Deviation	Maximum pixel point	Entropy	Standard deviation	Affected pixel point	Normal pixel point
Image 045	165.289	191.877	1.414	65.705	2590.582	88834.516

5.3 FINAL CLASSIFICATION AND RESULT

By analyzing all the features and parameters the results are displayed as **"INPUT IMAGE NORMAL (or) "INPUT IMAGE AFFECTED"**.The final result of normal is shown in figure 5.17.

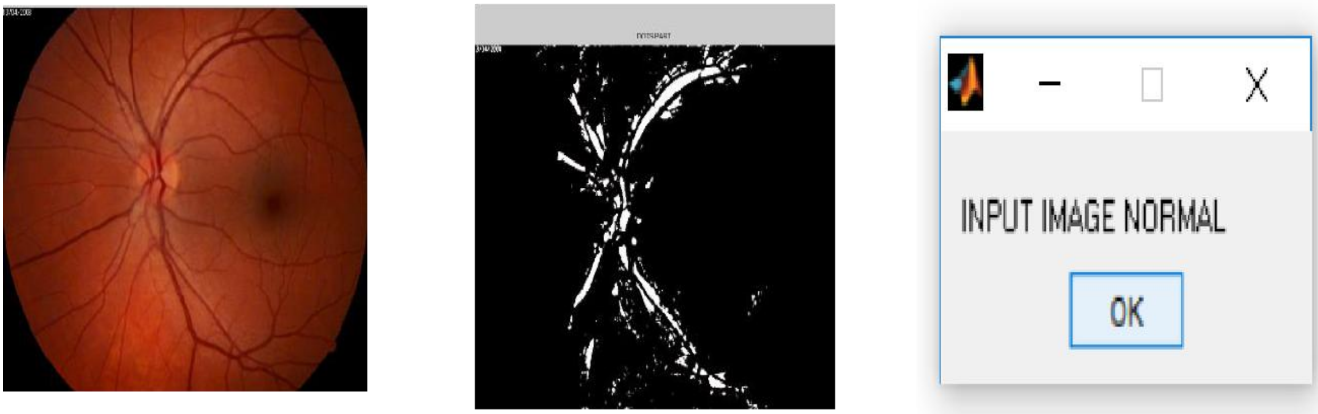

Figure 5.17 Final result of normal eye

The final result of affected eye is shown in figure 5.18

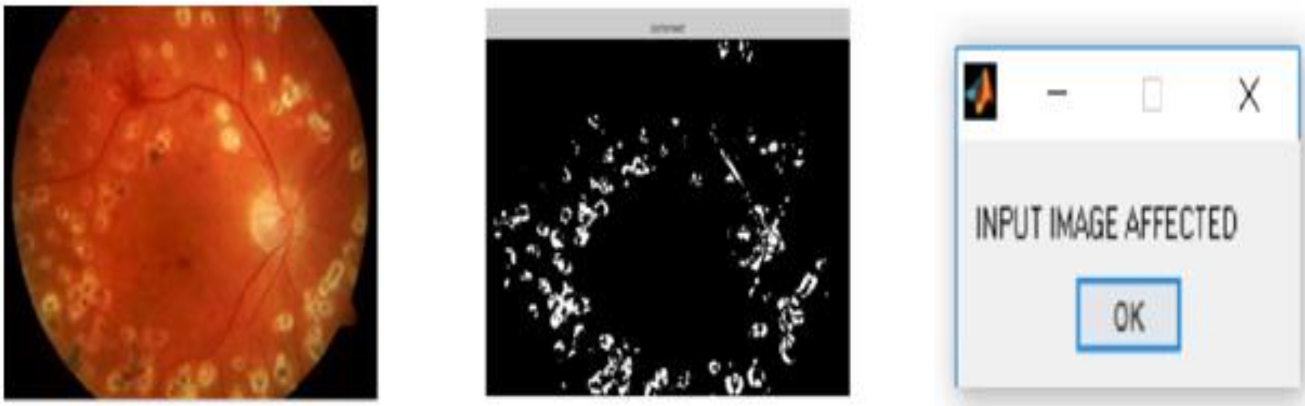

Figure 5.18 Final result of affected eye

In normal eye blood vessel there is no growth of blood vessel and no blood leakage.

Where as in abnormal eye there is more amount of blood leakage and emergence of new blood vessels.

5.4 PARAMETERS

5.4.1 Normal eye

Various parameters of all normal eye image in data set is shown in table 5.3.

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Table 5.3 Parameters of all normal eye image in data set

A	B	C	D	E	F	G	H
S.NO	IMAGE NUMBER	DEVIATION	MAXIMUM PIXEL POINT	ENTROPHY	STANDARD DEVIATION	AFFECTED PIXEL POINT	NORMAL PIXEL POINTS
1	1	176.358	197.858	1.405	60.738	2.791	91422.311
2	4	182.986	214.569	1.412	62.647	4.185	91420.913
3	7	182.418	215.719	1.416	62.555	4.185	91420.912
4	8	180.46	211.802	1.422	61.807	16.74	91408.3
5	10	182.712	211.386	1.414	62.575	2.79	91422.307
6	11	176.358	197.858	1.405	60.738	2.79	91422.312
7	12	182.418	215.719	1.416	62.551	4.185	91420.912
8	14	186.158	216.341	1.372	62.559	4.1851	91420.912
9	15	181.13	210.979	1.421	62.082	2.79	91422.307
10	16	179.5	202.218	1.421	61.484	122.763	91302.334
11	18	174.931	201.1	1.378	59.711	8.3702	91416.727
12	21	182.969	217.491	1.413	62.976	57.1964	91367.901
13	23	170.783	199.329	1.276	51.44	216.02	91206.077
14	24	183.834	214.212	1.405	62.929	21.9	91397.197
15	Image 003	143.93	172.238	1.567	62.201	219.02	91206.077
16	Image 004	171.988	200.38	1.494	62.391	0	91425.098
17	Image 043	172.352	204.456	1.494	61.398	0	91425.098
18	Image 046	174.03	206.785	1.488	60.351	58.591	91366.506
19	Image 047	170.531	198.425	1.414	52.093	115.788	91309.31
20	Image 040	173.903	201.504	1.489	60.644	29.295	91395.802
	AVERAGE	**185.105**	**205.518**	**1.426**	**63.004**	**44.679**	**91379.96**

Ranges of parameters of normal eye :
Standard deviation lies in the range between 55 - 63.
Affected pixel point lies in the range between 0 – 290
Normal pixel point lies in the range between 91000 – 92000 as per reference paper[9].

5.4.2 AFFECTED EYE

Various parameters of all affected eye images in data set is shown in table 5.4.

Table 5.4 Parameters of all affected eye images in data set

S.NO	IMAGE NUMBER	DEVIATION	MAXIMUM PIXEL POINT	ENTROPHY	STANDARD DEVIATION	AFFECTED PIXEL POINT	NORMAL PIXEL POIN
1	3	160.879	182.347	0.694	70.851	412.93	91012.
2	9	172.341	204.94	1.34	69.106	756.109	90668.
3	12	182.48	211.305	1.416	63.493	341.783	91083.
4	13	172.95	189.82	1.345	68.995	1037.906	90387.
5	17	180.533	203.272	1.422	63.872	313.883	91111
6	19	184.382	211.209	1.399	63.066	729.633	90695.
7	20	180.604	206.455	1.424	63.181	1343.419	90754.
8	22	187.31	216.99	1.349	63.913	671.012	90754.
9	Image 035	170.804	200.724	1.489	68.354	661.247	9076
10	Image 013	171.333	199.138	1.492	68.881	3648.019	87777.
11	Image 015	163.14	187.8	1.348	64.192	669.617	9075
12	Image 005	170.11	199.571	1.484	68.141	754.714	90670.
13	Image 006	171.827	203.318	1.491	68.796	749.134	90675.
14	Image 007	165.323	180.554	1.443	67.031	694.728	90730.
15	Image 016	172.516	202.36	1.495	69.756	725.418	90699.
16	Image 042	168.609	193.068	1.468	67.246	5868.917	8555
17	Image 044	162.506	190.647	1.415	66.99	636.136	90788.
18	Image 019	173.838	202.31	1.489	70.17	876.082	90549.
19	Image 017	169.598	200.356	1.482	68.048	382.239	91042.
	AVERAGE	**163.705**	**189.309**	**1.324**	**63.689**	**1054.69**	**85569**

Ranges of parameters of affected eye :
Standard deviation lies in the range between 63-75. Affected pixel point lies in the range of 290 and above
Normal pixel point lies in the range of 91000 and below as per reference paper[9].

5.5 DOCTOR'S OPINION FOR NORMAL EYE

Doctor's confirmation for normal eye is shown in table 5.5

Table 5.5 Doctor's verification for normal eye

IMAGE NUMBER	STANDARD DEVIATION	AFFECTED PIXEL POINT	NORMAL PIXEL POINTS	DOCTOR'S OPINION
1	60.738	2.791	91422.311	YES
4	62.647	4.185	91420.913	YES
7	62.555	4.185	91420.912	YES
10	62.575	2.79	91422.307	YES
Image 004	62.391	0	91425.098	YES
Image 047	52.093	115.788	91309.31	YES
Image 040	60.644	29.295	91395.802	YES
8	61.807	16.74	91408.3	YES
11	60.738	2.79	91422.321	YES
12	62.551	4.185	91420.912	YES
14	**62.559**	**754.714**	**90670.383**	**NO**
15	62.082	2.79	91422.307	YES

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16	61.484	122.763	91302.334	YES
18	59.7111	8.3702	91416.727	YES
21	62.976	57.1964	91367.901	YES
23	51.44	216.02	91206.077	YES
24	62.929	21.9	91397.197	YES
Image 003	62.201	219.02	91206.077	YES
Image 043	61.398	0	91425.098	YES

5.6 DOCTOR'S OPINION FOR AFFECTED EYE

Doctor's confirmation for affected eye is shown in table 5.6

Table 5.6 Doctor's verification for affected eye

IMAGE NUMBER	STANDARD DEVIATION	AFFECTED PIXEL POINT	NORMAL PIXEL POINTS	DOCTOR'S CONFIRMATION YES
9	69.106	756.109	90668.988	YES
13	68.995	1037.906	90387.191	YES
	68.881	3648.019	87777.078	YES
Image 013				
	67.246	5868.917	85556.18	YES
Image 042				
	68.141	754.714	90670.383	YES
Image 005				
20	63.181	1343.419	90754.085	YES
	66.99	636.136	90788.961	YES
Image 044				
3	70.851	412.93	91012.167	YES
12	63.493	341.783	91083.314	YES
17	63.872	313.883	91111.21	YES
20	63.181	1343.419	90754.085	YES
22	63.913	671.012	90754.085	YES
Image 035	68.354	661.247	90763.85	YES
Image 015	64.192	669.617	90755.48	YES
Image 006	68.796	749.134	90675.963	YES
Image 007	67.031	694.728	90730.369	YES
Image 016	69.756	725.418	90699.678	YES
Image 042	67.246	5868.917	85556.8	YES

59 images out of 60 images gives the exact result. Thus, the accuracy of the project is 98.33%

VI. CONCLUSION AND FUTURE WORK

Screening of diabetic retinopathy automatically is very difficult and it is important as it helps the eye specialists to diagnose the various grades of diabetic retinopathy during the examination of the eye which is accomplished by the combination of various steps such as the integrated use of morphological operations along with adaptive super pixel algorithm. This helps doctors to cure patients at the earlier stage and also prevents eye transplantation. The severity of the diabetic retinopathy can be further graded based on the detected lesions and their quantities. The performances of the method were also measured by specificity 95% and accuracy 98.33%.In the future work, identifying more features that will improve the performance of adaptive super pixel algorithm.. The accuracy can also be increased by improving the performance of the data or even by algorithm tuning. In addition, this system can be used to detect other retinal diseases.

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