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Design a Novel Detection for Maculopathy Using Weightage KNN Classification

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Abstract. Diabetic Maculopathy is damage to the macula. Scientifically also known as a pathological disorder. It's a very serious upshot of diabetes. Maculopathy early detection is very important as it causes blindness and is irreversible if proper treatment is taken. The present study deals with the design of a novel detection technique for early diagnosis of the diabetic maculopathy. For that Digital image processing have been used and for extracting the feature wavelet Filter has been used. Weighted KNN classification technique for grading of image i.e. mild, moderate and sever on the standard fundus images. The blood vessel extraction of the retina is first preferred because when macula starts getting affected by diabetes at the same time some abnormal blood vessel is created which is known as neovascularization. This Neovascularization cause's blindness because the retina gets nourishes with the blood vessels that's why blood vessel extraction is very important. Diabetic Maculopathy is one of the complications of diabetes mellitus that is considered as the major cause of vision loss among people around the world. It results from the leakage of fluid rich in fat and cholesterol from the damaged retinal vasculature. Accumulation of these fluids called exudates near the center of the retina. Development of diabetic Maculopathy is slow and silent, very frequently without any symptoms in the early stages. If Maculopathy is not detected in the early stage then the damage of the macula or visual field is irreversible and can lead to blindness. Therefore, compulsory regular screening of diabetic eye will help to identify the Maculopathy at the initial stage and reduce the risk of severe vision loss. Digital screening of Maculopathy results in the generation of a large number of retinal images to be Manually analyzed by an expert [2]. This often leads to observer fatigue and increase in the time taken for diagnosis. Non clinically significant (NCSME) and clinically significant (CSME) are two types of maculopathy stages. AQ1

Keywords: Macula · Blood vessel · Digital image processing

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1 Introduction

Diabetes. Diabetes is the long term disorder, when body cannot increase the insulin or the percentage of sugar is high than normal in the body that time we say it is a diabetic mellitus. Normal person sugar range is between 70 to 99 mg/dl and diabetes patient sugar range is more than 99 mg/dl means it may be between 100 to 126 mg/dl. Long term diabetes may affect on human organ like kidney, heart, eye, nerves, and blood vessels. Diabetes mellitus mainly are divided in two types Type I and Type II. In Type I body cannot produce Insulin and is generally diagnosed in children and young people. In which patient are given an insulin injection [1]. In Type II it does not respond to insulin. This type of diabetes is diagnosed in middle age or aged people. Both types are chronically lead high blood sugar levels. Both increases the risk of complications. Diabetes symptom are like frequent urination, drinking a lot of water, want to eat more means feeling hungry more than usual, feeling very fatigued, having a blurry vision because it affected on the human organ. When blood sugar goes high in the body that i.e. it gets affected a blood vessel causing leakage of fluid rich in fat and cholesterol from the damaged retinal vasculature. Accumulation of these fluids called exudates near the center of the retina if these types of results are shown in the retina or if a center of retina means that macula gets affected, and results in blindness it is called as diabetic maculopathy.

Diabetic Maculopathy. Diabetic Maculopathy is one of the complications of diabetes mellitus that is considered as the major cause of vision loss among people around the world. It results from the leakage of fluid rich in fat and cholesterol from the damaged retinal vasculature. Accumulation of these fluids called exudates near the center of the retina. Development of diabetic Maculopathy is slow and silent, very frequently without any symptoms in the early stages. If Maculopathy is not detected in the early stage then the damage of the macula or visual field is irreversible and can lead to blindness. Therefore, compulsory regular screening of diabetic eye will help to identify the Maculopathy at the initial stage and reduce the risk of severe vision loss. Digital screening of Maculopathy results in the generation of a large number of retinal images to be Manually analyzed by an expert [2]. This often leads to observer fatigue and increase in the time taken for diagnosis. Non clinically significant (NCSME) and clinically significant (CSME) are two types of maculopathy stages.

2 Methodology

The present study deals with the design of a novel detection technique for early diagnosis of the diabetic maculopathy. For that we used standard fundus image database which is STARE [4], DRIVE [5], DIRETDB0 [6], and DIRETDB1 [7] in which from STARE 35 images were taken, from DRIVE 20 images, that from DIRECTDB0 25 images and from DIRECTDB1 20 images were taken, these database are publically available in open sorce, and then Digital image processing have been used and for feature extraction we used wavelet Filter. Weighted KNN classification technique which is a supervised type of classification technique

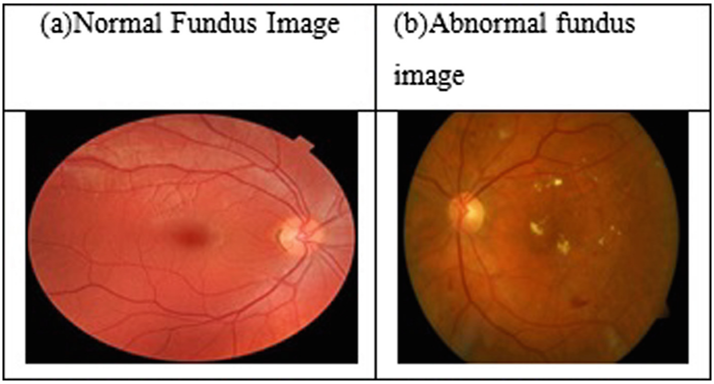

Fig. 1. Normal and abnormal fundus image.

have been used for grading of image i.e. mild, moderate and severe on the standard fundus images. The blood vessel extraction of the retina is first preferred because when macula starts getting affected by diabetes at the same time some abnormal blood vessel is created which is known as neovascularization. This neovascularization causes blindness because the retina gets nourishes with the blood vessels that's why blood vessel extraction is very important. For the extraction of Retinal blood vessel, the funds images are taken from a standardized database. From which, firstly, the extraction of green from Red Green Blue (RGB) image is done. After that secondly, the extraction of green channel, intensity transformation function has been applied to enhance the funds image. Then in third step, histogram equalization was applied on intensity transformed image because it highlighted the blood vessel. And then in the fourth step, morphological open function is applied for thinning the blood vessel. In fifth step, median filter is applied to remove noise which appeared when we used morphological open function. Then in the sixth step, threshold is applied for extraction of blood vessel and then in the seventh step apply Sym4 wavelet and extract the blood vessel. After the whole precess Area, Diameter, Length, Thickness and Mean Diameter is calculated. Normal blood vessel diameter are >25 mm through that value we predict the normal and abnormal images. Then apply Weighted KNN classification for grading the disease mild, moderate and severe (Fig. 1) . AQ2

2.1 Green Channel

In this process green channel plays an important role in following line figure showing red, green and blue channel with its histogram.

2.2 Red Channel

$$r = \frac{R}{(R + G + B)} \tag{1}$$

Here Red channel is viewed in which R, G, and B means Red Green and Blue respectively (Fig. 2).

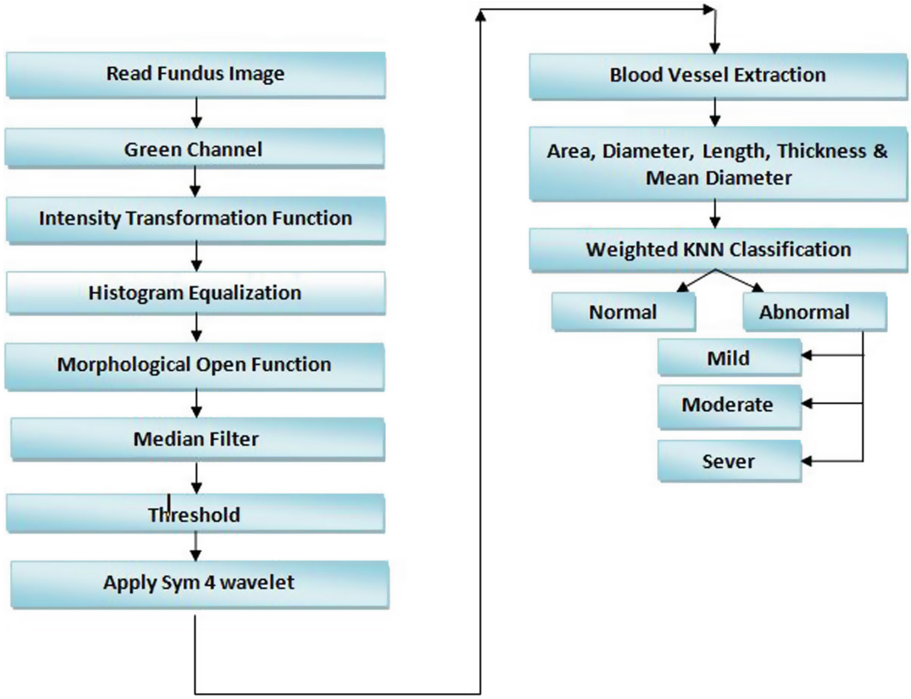

Fig. 2. Workflow of methodology

2.3 Green Channel

$$g = \frac{G}{(R + G + B)} \tag{2}$$

Here Green channel is viewed in which R, G, and B means that Red Green and Blue respectively.

2.4 Blue Channel

$$b = \frac{B}{(R + G + B)} \tag{3}$$

2.5 Intensity Transformation Function

The intensity transformation function is very easiest technique in image processing. If the need of an image is light lighter and dark darker at that time, it changes the intensity values, intensity transformation function which increase

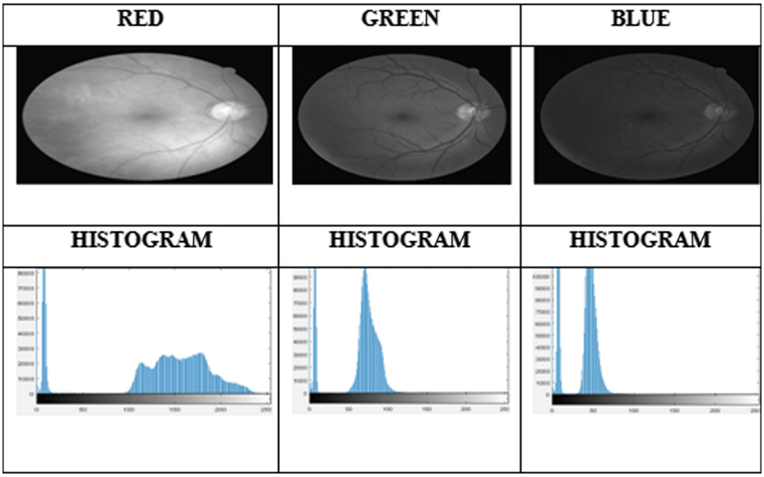

Fig. 3. Red, Green and Blue channel with histogram. (Color figure online)

contrast on certain value [15,16]. [8] The values of pixel pre and post processing are denoted to f(x, y) and g(x, y) (Fig. 3).

$$g(x, y) = Tf(x, y) \tag{4}$$

T for transformation of pixel value from f(x, y) into pixel (x, y). Input image is a f(x, y) and g(x, y) is output or processed image. [9] here we used intensity transformation for highlighting the retinal blood vessel.

2.6 Histogram Equalization

Histogram equalization produces output image with same allocation of pixel intensity means that the histogram of the output image is compress and increase systematically [10].

Here ps(s) and pd(d) is the image probability density functions. In following line we have histogram equalization of the image.

$$u = T(s)$$
$$T(s) = \int_0^s ps(x)dx \tag{5}$$

The histogram equalization image is acquired by a same transformation function as follows:

$$v = Q(d)$$
$$Q(d) = \int_0^d pd(x)dx \tag{6}$$

The values of d for the image are acquired as follows:

$$d = Q^{-1}[u]$$
$$Q^{-1}[u] = Q^{-1}T[s] \quad (7)$$

2.7 Morphological Open Function

In Digital image processing morphological open function use for the noise removal, it removes the small object from the foreground means that bright pixel of an image, placing then in the background [11].

2.8 Median Filter

Median filter use median value in its filtering process. It improves picture clarity improving, reduce least high and highest intensity value pixels and impulse noise [12].

2.9 Threshold

Thresholding is the way of partitioning an image foreground into background. This is a type of image segmentation that converts the grayscale image into binary image, it's very effective in an image with high level of contrast [13].

2.10 Wavelet

For the extraction of Diabetic maculopathy lesion we use here Wavelet filter. Here we used Symlet 4 wavelet. Wavelet performs a mathematical operation like image compression and decompose a signal into single representation and showing signal information. Wavelet can reduce noise and compress data and done many other operations. Wavelet computes the approximation coefficients matrix and details coefficients matrices i.e. horizontal, vertical, and diagonal, respectively. Here, inverse wavelet i.e. reconstructed image gives good result. The reconstructed or inverse wavelet have approximation coefficients matrix X, based on approximation matrix CA and details matrices CH, CV, and CD. In AQ3 that proposed study we used sym4 wavelet.

2.11 Blood Vessel Extraction

In blood vessel extraction we calculate the Area, Diameter, Length, Thickness and Mean Diameter. By following formulas.

2.11.1 Area

$$Area = \pi(r2) \quad (8)$$

2.11.2 Diameter

$$Diameter = \sqrt{\frac{Area}{\pi}} \tag{9}$$

2.11.3 Length

$$Length = \frac{Area}{2} \tag{10}$$

2.11.4 Thickness

$$Thickness = \frac{Area}{Length} \tag{11}$$

2.11.5 Mean Diameter

$$Mean = \frac{M}{c} \tag{12}$$

2.12 Weighted KNN Classification

Weighted KNN is the supervise classification technique which classify the data very easily [17]. Nominal Classes prediction is the main goal of classification version of weighted KNN and this classification works with the majority of the nearest neighbors and can be formulated by:

$$\hat{P}n\left(\omega_i|x\right) = \frac{p_n\left(x, w_i\right) \cdot w_i}{\sum_{i=1}^{M} p_n\left(x, w_i\right) \cdot w_i} = \frac{k_i \cdot w_1}{k \cdot w} \tag{13}$$

where w works as a function of the distance between the ith nearest neighbor and the test point. The distances on which the search for the nearest neighbors is based in the first step, have to be transformed into similarity measures which can be used as weights [14].

2.13 Experimentation and Result

The fundus images are taken from the standard database and extract the blood vessel in following line see the experiment on fundus image. In above experiment it can be seen that the abnormal blood vessel are born and some vessel are going to damage and some are already bleeding here blood vessel extraction experiment is done (Fig. 4).

Following table shows the blood vessel Area, Diameter, Length, Thickness And Mean Diameter in statistical format. Then using Weighted KNN classification, classification and grading has been performed. Here we only focused on Retinal blood vessel diameter if its statistical value is 25 so its is a normal retina if its greter than or less than 25 so its is a diabetic maculopathy retina. We also predict the grading range for mild moderate and sever (Fig. 5).

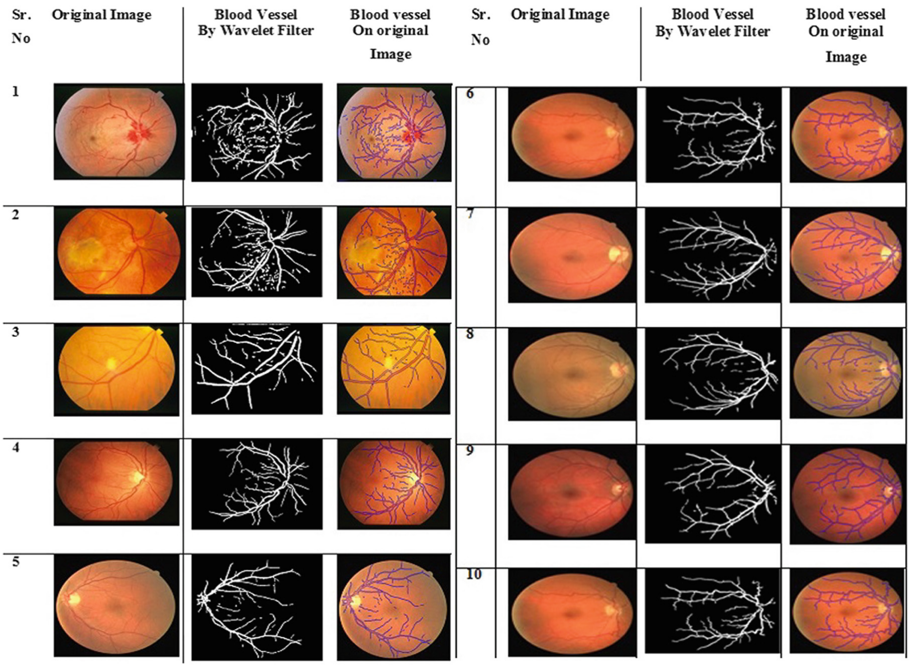

Fig. 4. Extraction of retinal blood vessels.

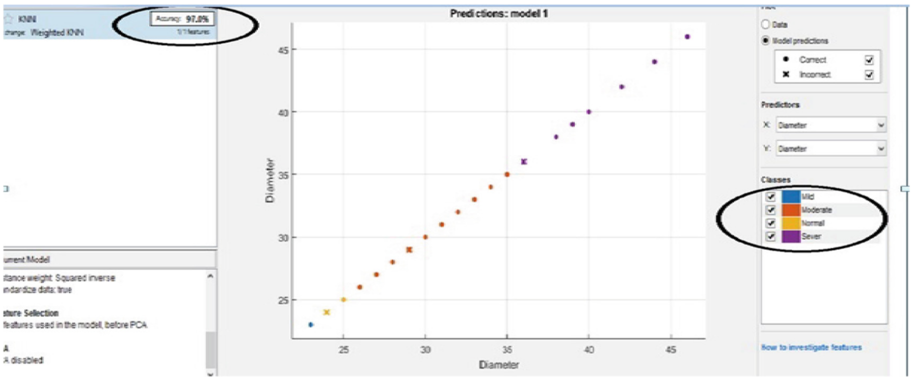

Fig. 5. Weightage KNN classification result. (Color figure online)

Classification and Grading. For the Classification and grading we used Weighted KNN supervise technique and we got the 97% accuracy on 100 fundus image, we also used a Support Vector Machine, Decision Tree, Linear Regression etc. classifier used but Weighted KNN is giving to much good result than other, thats why here we used Weighted KNN. In following figure we can see classifier accuracy and grading. In above figure we draw a black circle on result and grad-

Table 1. Statistical parameters of retinal blood vessels by symlet wavelet

Sr. no.	Area	Diameter	Length	Thickness	Mean diameter
1.	98.34875	32	49	2	20
2.	64.38625	26	32	2	20
3.	70.17125	27	35	2	20
4.	52.41125	23	26	2	20
5.	97.68875	31	49	2	20
6.	84.62875	29	42	2	20
7.	85.27375	29	43	2	20
8.	126.6763	36	63	2	20
9.	88.97	30	44	2	20
10.	87.79	30	44	2	20
11.	96.29375	31	48	2	2
12.	83.54625	29	42	2	20
13.	123.9963	35	62	2	20
14.	81.38375	29	41	2	20
15.	95.16125	31	48	2	20
16.	155.4675	40	78	2	20
17.	76.77875	28	38	2	20
18.	72.97	27	36	2	20
19.	83.04	29	42	2	20
20.	105.565	33	53	2	20
21.	82.82	29	41	2	20
22.	78.49375	28	39	2	20
23.	63.6525	25	32	2	20
24.	67.83125	26	34	2	20
25.	128.42	36	64	2	20
26.	96.39375	31	48	2	20
27.	84.655	29	42	2	20
28.	89.3725	30	45	2	20
29.	74.04375	27	37	2	20
30.	101.405	32	51	2	20
31.	122.345	35	61	2	20
32.	86.69	30	43	2	20
33.	126.6763	36	63	2	20
34.	117.2775	34	59	2	20
35.	109.3588	33	55	2	20
36.	141.445	38	71	2	20
37.	88.5375	30	44	2	20
38.	81.415	29	41	2	20

(*continued*)

Table 1. (*continued*)

Sr. no.	Area	Diameter	Length	Thickness	Mean diameter
39.	120.1463	35	60	2	20
40.	126.1963	36	63	2	20
41.	83.85	29	42	2	20
42.	127.305	36	64	2	20
43.	84.725	29	42	2	20
44.	76.4925	28	38	2	20
45.	128.9163	36	64	2	20
46.	88.2875	30	44	2	20
47.	89.47375	30	45	2	20
48.	100.9788	32	50	2	20
49.	62.41875	25	31	2	20
50.	70.72625	27	35	2	20
Bitmap sr. no.	Area	Diameter	Length	Thickness	Mean diameter
51.	83.08	29	42	2	20
52.	90.35	30	45	2	20
53.	100.2288	32	50	2	20
54.	83.41625	29	42	2	20
55.	65.0575	26	33	2	20
56.	85.315	29	43	2	20
57.	89.675	30	45	2	20
58.	70.795	27	35	2	20
59.	91.33	30	46	2	20
60.	82.89625	29	41	2	20
61.	79.0975	28	40	2	20
62.	94.30125	31	47	2	20
63.	81.91875	29	41	2	20
64.	80.125	28	40	2	20
65.	194.8813	44	97	2	20
66.	110.1225	33	55	2	20
67.	96.805	31	48	2	20
68.	80.63875	29	40	2	20
69.	90.43	30	45	2	20
70.	88.14	30	44	2	20
71.	62.565	25	31	2	20
72.	70.415	27	35	2	20
73.	123.75	35	62	2	20
74.	114.0988	34	57	2	20
75.	72.09125	27	36	2	20
76.	151.3663	39	76	2	20
77.	119.585	35	60	2	20

(*continued*)

Table 1. (*continued*)

Sr. no.	Area	Diameter	Length	Thickness	Mean diameter
78.	106.9825	33	53	2	20
79.	90.62375	30	45	2	20
80.	210.0325	46	105	2	20
81.	91.52125	30	46	2	20
82.	124.7875	36	62	2	20
83.	73.8575	27	37	2	20
84.	56.23875	24	28	2	20
85.	60.6425	25	30	2	20
86.	99.4975	32	50	2	20
87.	140.5138	38	70	2	20
88.	77.16125	28	39	2	20
89.	95.79375	31	48	2	20
90.	82.03875	29	41	2	20
91.	61.25125	25	31	2	20
92.	71.53875	27	36	2	20
93.	93.17375	31	47	2	20
94.	121.285	35	61	2	20
95.	174.755	42	87	2	20
96.	67.6075	26	34	2	20
97.	194.8813	44	97	2	20
98.	110.1225	33	55	2	20
99.	96.805	31	48	2	20
100.	80.63875	29	40	2	20

ing, first circle showing the accuracy of result and second showing the grading. Blue color showing the Mild, orange showing Moderate, Yellow showing Normal and Purple showing Sever of Diabetic maculopathy grading. PCA is disable there. In that Weighted KNN classification we used five fold cross validation it also called K-fold validation and get the 97% good result on database (Table 1).

3 Conclusion and Discussion

Blood vessel extraction is very important for maculopathy as it creates new abnormal blood vessels by which it not only damages the macula but increases high risk of vision loss. So to reduce this risk by Weighted KNN classification blood vessel have been extracted. In which area, diameter, length etc. has been extracted. And by calculating the diameter we can came to the conclusion that less than and greater than 25 mm. diameter the blood vessel is abnormal.

Weighted KNN classification gave 97% accuracy on standard database. As 97% is a good accuracy rate, the research is useful for ophthalmologist.

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