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Profiling of Hard Exudates and Microaneurysms to Evaluate the Progress of Diabetic Retinopathy

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Abstract—Diabetes also known as diabetes mellitus (DM) is a prominent disease all over the world. It is a metabolic disorder occurring due to high blood sugar levels over a prolonged period. Diabetes affecting macular area is called diabetic maculopathy. Prolonged diabetes will lead to diabetic retinopathy which affects retina. The identification, grading and quantification of the disease will help to know the progress of the disease. So developing automated systems for identification, grading and quantification of the retinal pathologies associated with DM is on the rise. The aim of this project is to grade the different stages of retinopathy in Colour Fundus images using quantitative features extracted from the images such asarea, location and count of the hard exudates and microaneurysms and to evaluate the progress of diabetic retinopathy. Developing new techniques for grading various types of diabetic retinopathy based on quantification algorithms will aid the clinicians to understand the progress of the disease, which in turn provides us with scope for further re-search. The image dataset has been collected from Amrita Institute of Medical Sciences and Research Center. Here the images are of size 2588*1958.This automation will help the doctors to analyse the level of the disease and provide necessary treatments.

Keywords-DM, Color Fundus, exudates, microaneurysms

I. Introduction

Diabetes is a problem which is affecting many people in this world. This is a problem which is affecting the human body due to raise in the blood sugar levels. There are different types of diabetics. The sugar level should be maintained in a particular level. In 2013 it was estimated that over 382 million people throughout the world had diabetes. It is due to either the pancreas not producing enough insulin or the cells of the body not responding properly to the insulin produced. Diabetics can also affect different body organs such as: heart, liver, eyes etc… Even it can cause serious health issues which may or may not lead to the death of a person. There are different types of diabetics. Some are type 1, type 2, gestational diabetics, type 3 etc…

There are different modalities by which treatment and diagnosis becomes easier. They are by: color stereo fundus photographs, fundus fluorescien angiogram, and optical coherence tomography and slit-lamp biomicroscopy. Color stereo fundus provides an opportunity to evaluate long-term changes in the retina. It also helps in identifying the cause of the vision loss.

There are mainly two types of diabetic retinopathy: Non-proliferative diabetic retinopathy and proliferative diabetic retinopathy. NPDR also known as background retinopathy is the early stage of diabetic retinopathy. In this stage, tiny blood vessels within the retina leak blood or fluid. The leaking fluid causes the retina to swell or to form deposits. It shows changes in eyes including: microaneurysms, retinal exudates, hemorrhages, macular edema and macular ischemia.

PDR mainly occurs when many of the blood vessels in the retina close, preventing enough blood flow. This may lead to create new blood vessels which help in supplying blood to the retina. As these blood vessels are abnormal it will not provide much blood to the retina. Hence it will create a loss in the vision. It affects vision by: vitreous hemorrhage, traction retinal detachment and neovascular glaucoma. PDR will affect the eyes more than NPDR.

The images for the methodology were collected form Amrita Institute of Medical Sciences and Research Center, Kochi. The images were of size 2588*1958. It includes 100 images of FA images and 75 images of FFA images. As we are working on FA images, we used the 100 images for testing the outputs.

II. METHODOLOGY

A. Methodology for quantifying the microaneurysms

Automated and reliable detection of edema is vital for early cure of the disease. Edema occurs when exudates appear near or on the macula, so automated detection of macula and exudates are important to construct a computer aided diagnostic system for DME. There are various computerized methods in the literature which are proposed for the detection of macula, exudates and edema. But in this method, the macular region is extracted manually so that it will help the doctors or the clinician to identify the exact region where the disease is affected.

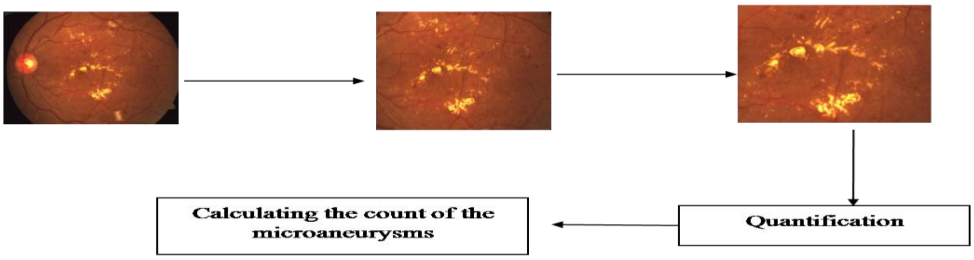

Figure 1: The architectural diagram of quantifying the microaneurysms

B. Algorithm for detection of microaneurysms

Step 1: Read the input image

Step 2: Apply the thresholding technique.

Step 2.1: Initial estimate of tk of is calculated at step k as

$$tk=l1+l22\ 4$$

Step 2.2: At step k, apply the threshold tk . This will produce two groups of pixels: Go consisting of all pixels belonging to object region and Gb consisting of all pixels belonging to background region.

Step 2.3: Compute the average intensity values $\mu 0$ and $\mu 1$ for the pixels in Go and Gb respectively.

Step 2.4: Update the threshold as follows:

$$tk+1=\mu 0k+\mu bk2$$

Step 2.5: Repeat steps 2 through 4 differences in T in successive iterations.

Step 3: Extracted the original shade corrected image (a top-hat transformation) and apply the mask

Step 4: Display the count of the microaneurysms.

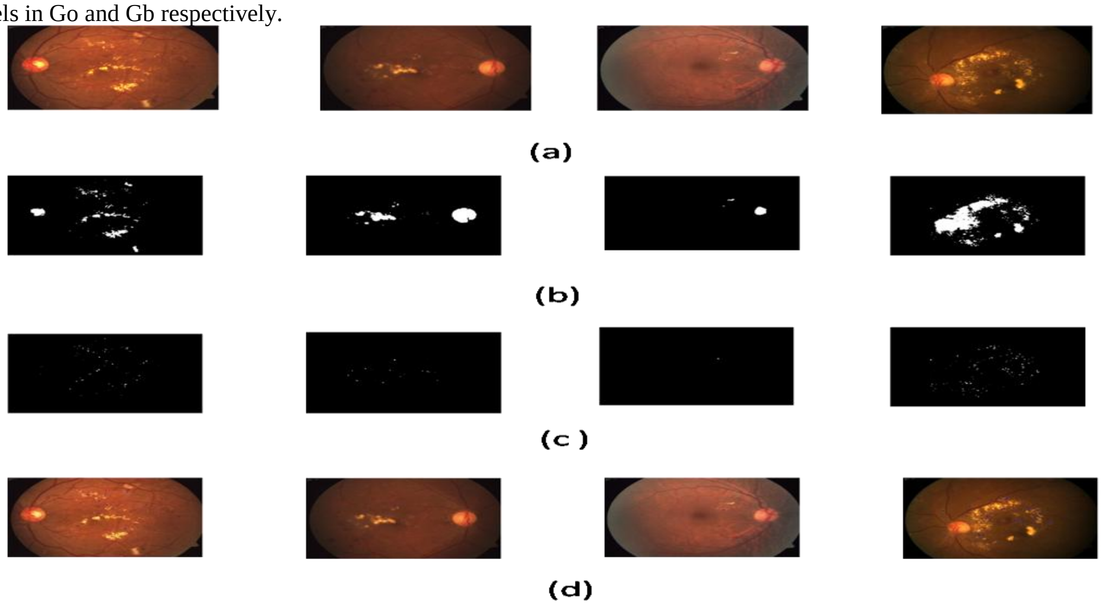

Figure 3: (a) the retinal input image. (b) The result obtained when thresholding is applied. (c) the results obtained when mask is applied to extract the microaneurysms. (d) displaying the microaneurysms detected.

The macula is a depression in the center of macular region and appears as a darker area in a color retinal image. It is located temporal to the optic disc and has no blood vessels present in its center. In a retinal image, the contrast of macula is often quite low and sometimes it may be obscured by presence of exudates or hemorrhages in its region. As a consequence a search to obtain a global correlation often fails. Therefore, the macula is localized based on its distance and position with respect to the optic disc as it remains relatively constant. Since the location of macula varies from individual to individual, a rectangular search area has to be defined. In a standard retinal image the macula is situated about 2 disc diameter (DD) temporal to the optic disc. So the macular area is cropped out after 2DD distance.

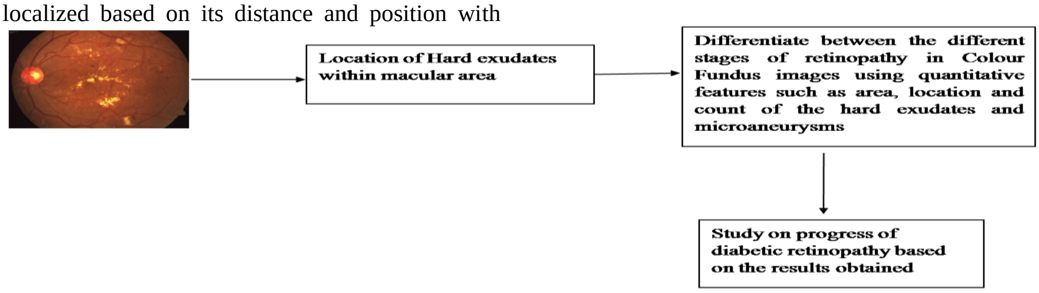

Figure 2: The architectural diagram for quantifying the exudates

D. Algorithm for detecting exudates

Location, Area and Count of Hard Exudates

Algorithm for the detection of exudates

Step 1: Read the image

Step 2: Draw a rectangle over the portion of the image which is located 2DD distance.

Step 3: Select the crop operation and the cropped image is stored in the specified location.

Step 4: Converting the cropped color image into gray scale image.

Step 5: Locating the exudates using histogram based method.

Step 6: Counting the exudates in the macular area

Step 7: Display the count

Calculating the Area and location of the exudates:

The area of the macular region is calculated by using regionprops() function. The macular region is cropped from the original retinal image. Imtool is used for calculating the current location of the exudates. This command will help in reading the image from the file and by pointing it to the current portion of the exudates, it will show the location.

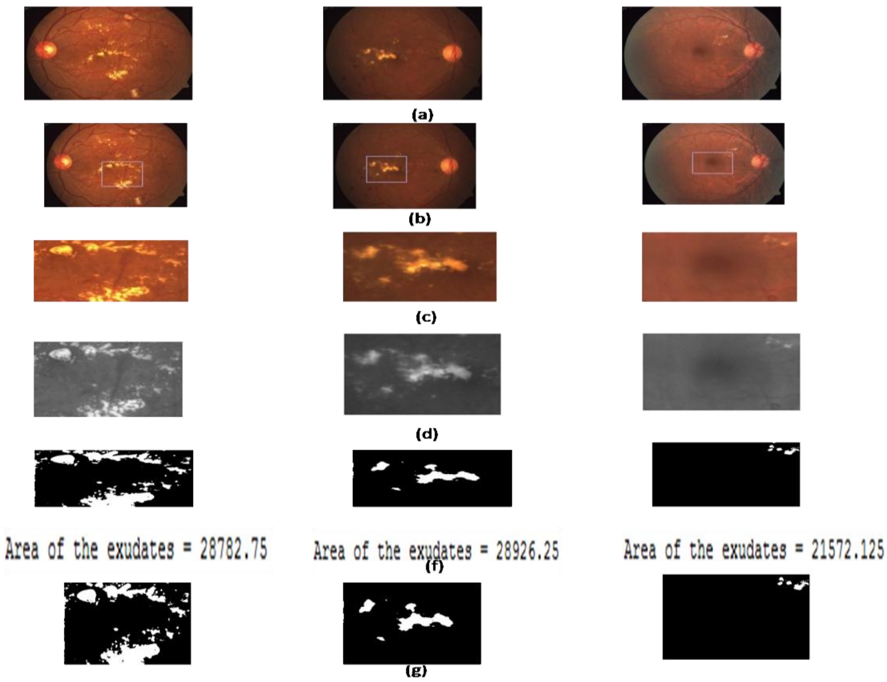

Figure 4: (a) the retinal input image. (b) Cropping the macular area in rectangular shape. (c) the macular region cropped out. (d) Binary image of the macular region. (e) Detecting the exudates present in the macular region. (f) Displaying the area of the exudates. (g) Locating the exudates

III. VALIDATION

The table below shows the tabulation of the area, location and count of the exudates present the retinal images.

Table 1: Tabulation of area, location, count of microaneurysms and count of exudates

Images	PDR				NPDR			
	Count of hard exudates	Location of exudates	Area	Count of microaneurysms	Count of hard exudates	Location of exudates	Area	Count of microaneurysms
1	2	(144,122)	21844.3	88	5	(88,100)	21970.5	2
2	1	(225,155)	19657.5	5	14	(145,175)	24372.8	31
3	35	(98,111)	32785.1	56	27	(168,188)	19892.2	68
4	8	(200,191)	20176.7	24	68	(157,120)	34008.6	184
5	24	(89,100)	28387.6	147	34	(163,100)	32601.6	87
6	18	(121,152)	21889	52	9	(98,121)	21930.7	41
7	52	(164,185)	23678.1	48	31	(156,191)	32004.5	18
8	50	(130,162)	22049.8	36	15	(124,169)	22265	21
9	2	(144,100)	23509	22	20	(179,111)	27095.1	20
10	41	(88,77)	48482.1	18	6	(80,52)	21844.1	16
11	1	(85,111)	24818.3	32	20	(200,136)	19842.3	19
12	1	(56,89)	20544.1	62	126	(197,164)	2598.3	77
13	78	(123,148)	30752.1	19	33	(222,156)	26184.2	38
14	79	(224,122)	41476.5	10	32	(99,158)	21204	24
15	53	(168,145)	45649.2	50	23	(89,111)	33012.2	41
16	18	(135,175)	26286.5	41	42	(148,188)	12897.1	27
17	42	(122,100)	25451.5	9	50	(176,173)	20014.5	21
18	57	(154,120)	19842.2	21	14	(100,143)	26421.5	23
	31.22±26.3		30237.7±9008.8	41.1±34.1	31.4±28.5		25085.5±7620.5	42.0± 41.9

According to the analysis of the results from Table 1, we can say that the count of the hard exudates, show only a marginal difference between NPDR and PDR. While considering the second parameter of area of the exudates, it is clear that the area of the exudates is high in case of PDR than that of NPDR. The locations of the hard exudates are also observed, but the location of the hard exudates within the macular area did not show any significant differences between the presence of NPDR and PDR. The last parameter considered is the count of the microaneurysms, it is observed that the value of the count is high in case of NPDR.
So it can be concluded that the factors such as: the count of the exudates, count of the micro aneurysms and the area will help in the categorizing NPDR and PDR, whereas location of the exudates within the macular area does not play a vital role in the categorization. Through this project we have established that we can differentiate between the different stages of retinopathy in Colour Fundus images using quantitative features extracted from the images which has not been tried so far in the Literature. We believe that this will help the clinicians to understand the severity of the disease and provide the treatment accordingly. The results can be validated further depending on the availability of the dataset.

IV. CONCLUSION

Here, we differentiated between the different stages of retinopathy in Colour Fundus images using quantitative features extracted from the images such as area, location and count of the hard exudates and microaneurysms. Developing new techniques for grading various types of diabetic retinopathy based on quantification algorithms will aid the clinicians to understand the progress of the disease, which in turn provides us with scope for further re-search. Different image processing techniques have been used and have been applied to the dataset that has been provided. The index developed here is computationally efficient for the analysis of different types of diabetic retinopathy. We believe that this will help the clinicians to understand the severity of the disease and provide the treatment accordingly. The results can be validated further depending on the availability of the dataset.

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