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Automatic Detection of Non-Proliferative Diabetic Retinopathy Using Fundus Images

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Abstract: *To diagnosis of Diabetic Retinopathy (DR) it is the prime cause of blindness in the working age population of the world. Detection method is proposed to detect dark or red lesions such as microaneurysms and hemorrhages in fundus images.Developed during this work, this first is for collection of lesion data information and was used by the ophthalmologist in marking images for database while the automatic diagnosing and displaying the diagnosis result in a more friendly user interface and is as shown in chapter three of this report. The primary aim of this project is to develop a system that will be able to identify patients with BDR and PDR from either colour image or grey level image obtained from the retina of the patient. The algorithm was tested fundus images. The Operating Characteristics (ROC) was determined for red spot lesion and bleeding, while cross over points were only detected leaving further classification as part of future work needed to complete this global project. Sensitivity and specificity was calculated for the algorithm is given respectively as 96.3% and 95.1%.*
Keywords:*Diabetic Retinopathy, Retinal Fundus Image, Digital Image Processing, microaneurysm, Classifier.*

I. Introduction

Diabetic retinopathy (DR) is a leading cause of blindness in the world. The energy required by the body is obtained from glucose. Digested food go in the body stream with the assistance of a hormone called insulin which is produced by the pancreas. During eating, the pancreas automatically produces the correct amount of insulin needed for allowing glucose absorption from the blood into the cells. In individuals with diabetes, the pancreas either produces too little or no insulin or the cells do not react properly to the insulin that is produced. The increase of glucose in the blood, overflows into the urine and then passes out of the body. Therefore, the body loses its main source of fuel even though the blood contains large amounts of glucose [2].The rate of diabetes is increasing, not only in developed countries, but in underdeveloped countries as well. Unfortunately, most developing countries lack basic recoding of DR cases. It is estimated that 75% of people with diabetic retinopathy live in developing countries. The situation in developing countries is especially bad, because there is inadequate treatment. Regardless of the health care situation in their country of origin, people with diabetes are 25 times more likely to develop blindness when compared with individuals who do not suffer from this disease.[3]

The country population has been diagnosed of diabetes disease alone and it have been recognize and accepted as one of the main cause of blindness in the country if not properly treated and managed. Early detection and diagnosis have been identified as one of the way to achieve a reduction in the percentage of visual impairment caused by diabetes with more emphasis on routine medical check which the use of special facilities for detection and monitoring of the said disease [1]. The effect of this on the medical personnel need not be over emphasized, it has lead to increase work load on the personnel and the facilities, increase in diabetes screening activities just to mention a few. A lot of approaches have been suggested and identified as means of reducing the stress caused by this constant checkup and screening related activities among which is the use medical digital image signal processing for diagnosis of diabetes related disease like diabetic retinopathy using images of the retina.

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 three stages viz: Background Diabetic Retinopathy (BDR), Proliferate Diabetic Retinopathy (PDR) and Severe Diabetic Retinopathy (DR). In BDR phase, the arteries in the retina become weakened and leak, forming small, do like haemorrhages[4]. These leaking vessels often lead to swelling or edema in the retina and decreased vision. In the PDR phase, circulation problems cause areas of the retina to become oxygen-deprived or ischemic. New fragile, vessels develop as the circulatory system attempts to maintain adequate oxygen levels within the retina. This phenomenon is called neovascularisation. Blood may leak into the retina and vitreous, causing spots or floaters, along with decreased vision [6]. In the SDR phase of the disease, there is continued abnormal vessel growth and scar tissue, which may cause serious problems such as retinal detachment and glaucoma and gradual loss of vision. This research work is one of the method of applying digital image processing to the field of medical diagnosis in order to lessen the time and stress undergone by the ophthalmologist and other members of the team in the screening, diagnosis and treatment of diabetic retinopathy[7]. This work determine the presence of BDR and PDR or otherwise in a patient by applying techniques of digital image processing on fundus images taken by the use of medical image camera by a medical personnel in the hospital.

II. Methods

1.1. Pre-Processing

In detecting abnormalities associated with fundus image, the images have to be PreProcessed in order to correct the problems of uneven illumination problem, nonsufficient contrast between exudates and image background pixels and presence of noise in the input fundus image. Aside from aforementioned problems, this section is also responsible for colour space conversion and image size standardization for the system.

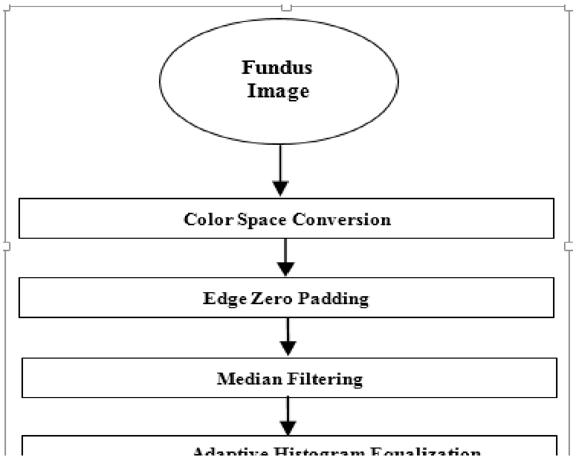

Fig.1 Block diagramof Pre-Processing

This section, which is Pre-Processing stage, can be regarded as the bedrock of this research work. The block diagram of the sub sections that constitute the Pre-Processing.

1.2. Median Filtering

Applying adaptive histogram equalisation to an image to enhance the contrast between the background pixels and the information contained in the image also lead to enhancement of the noisy pixels. A noisy pixels appears with the background information, therefore there is need to remove noisy pixels before contrast enhancement using a Median filter. Median filtering has been discussed in detail in Chapter 3 hence no need of detail discussion here.

1.3. Histogram Equalisation

One of the problems associated with fundus images is uneven Illumination. Some areas of the fundus images appear to be brighter than the other. Areas at the centre of the image are always well illuminated, hence appears very bright while the sides at the edges or far away are poorly illuminated and appears to be very dark. In fact the illumination decreases as distance form the centre of the image increase. Many methods were tried in resolving this problem of un-even illumination, among which are the use of Naka Rushton method and Adaptive Histogram Equalisation Method (AHEM). AHEM gives better performance, higher processing speed and work well for all images of different sizes, hence the reason for it being used as method of correcting un-even illumination. Nevertheless the two methods will be discussed in this sub section.

1.4. K-mean Clustering Algorithm of Segmentation

The K-means is another simple algorithm of segmenting or classifying images into k different clusters based on feature, attribute or intensity value. It is computationally efficient and does not require the specification of many parameters as compared to other method of segmentation. Unlike local thresholding, which can only group into two main classes while K-mean Algorithm can group into k different classes and that is part of the reason why we chosen as segmentation method for this work. The classification is done by minimizing the sum of the squares of distances between data and the corresponding clustering centroid. Type of distance calculation compatible with K-means Algorithm includes Manhalanobis and Euclidean distance etc.

Algorithm for K-means Segmentation

1: Input data and number of clusters

2: Calculate cluster (group) centroids based on initial guess value
3: Calculate distance of each pixel from Class centroid
4: Group pixels into k clusters based on minimal distance from centroids
5: Calculate new centroid for each cluster
6: Classify into groups based on new centroid and distance Step 7: Test if any of centroid changes its position.
8: If there are changes repeat step 3- 8, else step 9
9: end

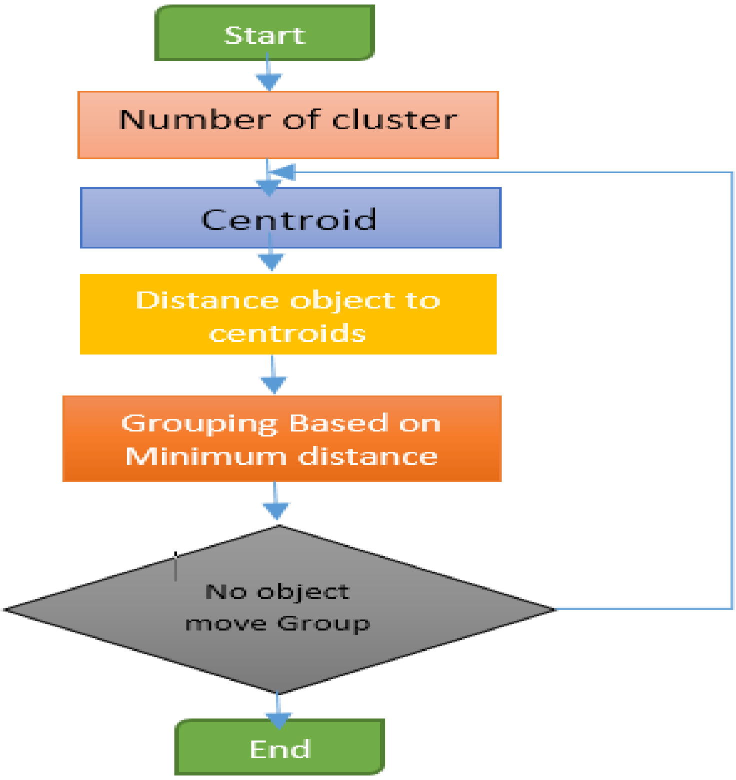

Fig2. Flow Chart, of K-Mean

1.5. Median Filtering

The median filter is a nonlinear filter, which can reduce impulsive distortions in an image and without too much distortion to the edges of such an image. It is an effective method that of suppressing isolated noise without blurring sharp edges. Median filtering operation replaces a pixel by the median of all pixels in the neighbourhood of small sliding window. It gives better results then the neighbourhood averaging in the case where noise is of impulsive nature. The advantage of a median filter is that show in Fig. 3.(b) it is very robust and has the capability to filter only outliers and is thus an excellent choice for the removal of especially salt and pepper noise and horizontal scanning artefacts. The median filter is realized in MATLAB by the function medfilt2.

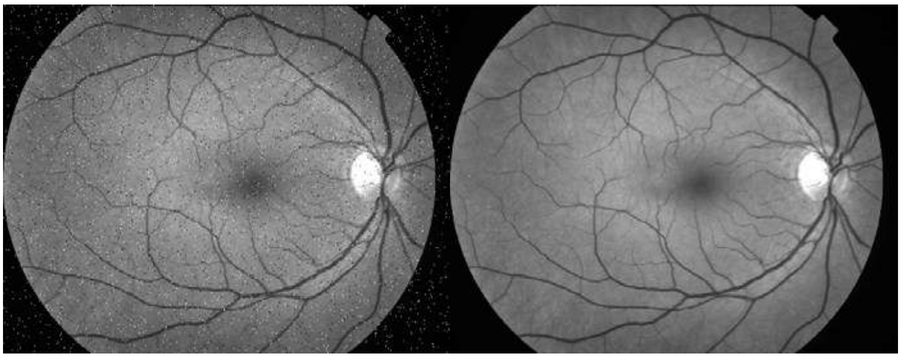

Fig. 3.(a) Image before apply Median Filtering (b)After Median FilteringImage

1.6. Morphological Operations

Morphological operations play a key role in digital image processing and its special application machine vision and automatic object detection. The basic operations are shift-invariant (translation invariant) operators strongly related to addition.

Let *E* be a Euclidean space or an integer grid, and *A*a binary image in *E*.

1.6.1. Dilation

Dilation of *A* by the structuring element *B* is defined by

$$A \oplus B = \bigcup_{b \in B} A_b \quad .$$

The dilation is commutative, also given by:

$$A \oplus B = B \oplus A = \bigcup_{a \in A} B_a \quad .$$

The dilation of A by A_s is the set consisting of all structuring element origin locations where the reflected and transmitted A_s overlaps at least some portions of A. Dilation operation is commutative and associative.For example, the erosion of a square of side 10, centered at the origin, by a disc of radius 2, also centered at the origin, is a square of side 6 centered at the origin.

1.6.2. Erosion

The erosion of the binary image *A* by the structuring element *B* is defined by:

$$A \ominus B = \{z \in E | B_z \subseteq A\},$$

whereB_z is the translation of *B* by the vector *z*,

i.e., $B_z = \{b + z | b \in B\}, \forall z \in E.$

If B has a center on the origin, as before, then the dilation of A by B can be understood as the locus of the points covered by B when the center of B moves inside A. In the above example, the dilation of the square of side 10 by the disk of radius 2 is a square of side 14, with rounded corners, centered at the origin. The radius of the rounded corners is 2.

III. Result

DIARETDB1 These databases contain overall 89 retinal images with a resolution of 1500 × 1152 pixels and of different qualities in terms of noise and illumination. Images were captured using the same 150◦ FOV digital fundus camera with varying imaging settings. Fig.4. (b) the output of classifier highlighting dark and bright lesions from retinal images respectively.Each of the points in the ROC in fig.4 (b) represent a set of classifier values used in the determining the best threshold value to be used for our algorithm.

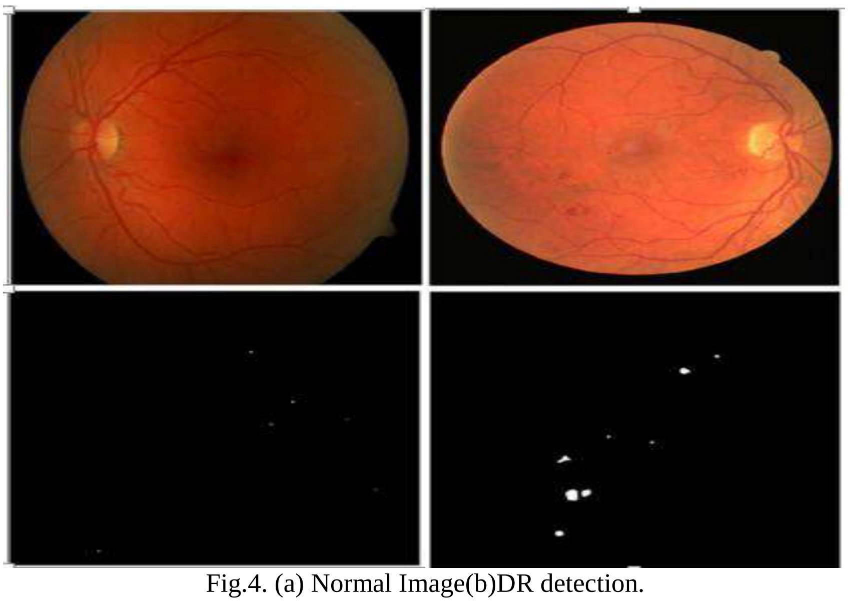

Fig.4. (a) Normal Image(b)DR detection.

In detecting abnormalities or otherwise, the presence of at least, quantity five of the sum of the disease analyzed above, i.e. red spot or/and bleeding points in an image leads to the image being classified as abnormal image. The only exception to this is the crossover points, there are two types of vein artery crossover in fundus images, and one is regarded as normal crossover point while the other is regarded as abnormal crossover. The abnormal crossing occurs when and artery crosses a vein and during the high blood pressure it presses the vein and causes a stop of the blood flow in vein.

Table 1: Result of DIARETDB1 proposed technique

Method	**Sensitivity (%)**	**Specificity (%)**	**Accuracy (%)**
Walter [10]	92.8%	92.4 %	100%
Wasif [11]	94.3%	92.0 %	100%
Proposed method	96.3%	95.1 %	96.67%

Because of this type of abnormal crossing of vein and artery bleeding can occur from vein at that point. All other types of vein-artery crossings are normal. In this work, vein artery crossings were detected only but further probing need to be done for classification. Detection for abnormalities is centred on detecting red spot disease and bleeding.

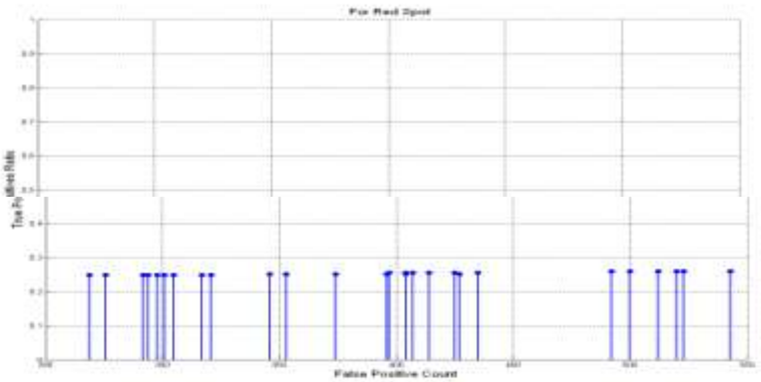

Fig.5Rate of Red Spot

Each of the points in the ROC Figure 5.1 represent a set of classifier values used in the determining the best threshold value to be used for our algorithm.

IV. Conclusion and Future Work

Development of automated system used by the ophthalmologist in marking fundus images. The marked images are to beused for the development of DR grading and database system for this present and future work. The quality of which is firstly improved by our method of Illumination equalization. The second achievement of this research work include the detection of red spots and bleeding in this work, though more work still need to be done in order to reduce the error due to over enhancement of noise and misdetection in this work. This is a 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. In line with the aims and objectives of this research work is to developed automated system for detect DR with a specificity of 96.3% and sensitivity of 95.1 %

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