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*Research Article*

# Detection of Macular Edema and Glaucoma from Fundus Images

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***Abstract***

*Diabetic macular edema (DME) is an eye disease that belongs to diabetic retinopathy which leads to vision loss. DME, which is a swelling in the macular region of eye is a common vision problem seen in diabetic patients.Hard exudates (bright lesions)in the fundus image indicates the presence of DME. When blood vessels in retina of diabetic patient is begin to leak into the macula region of eye leading to vision loss. Early detection of Macular Edema in diabetic patients prevents blindness. So in this article detection of exudates and its proximity towards macula determines and thereby its everity level. This article presents the computer based approach for the DME detection, which includes the steps image preprocessing, localization and masking of the optic disk, detection of fovea, ROI extraction, motion pattern generation, determination of disease severity level. First stage,detecting of DME and the next stage is assessing the severity of DME. Also this paper presents an automatic method for glaucoma detection.*

***Keywords:*** *Diabetic Macular Edema, Fundus images, Exudates,ROI, K-Means clustering, Cup to disc ratio(CDR)*

## 1. Introduction

Diabetes is a group of metabolic diseases seen in a person who has high blood sugar. Diabetic Retinopathy (DR) is one of the most common diabetic eye disease. DR occurs when blood vessels in the retina undergone various modifications and finally it get swell and leak. The global burden of diabetic patients is expected to 366 million in 2030 (S. Wild *et al.*, 2004) So it is very important to determine diabetic retinopathy in the earlier stage.

Diabetic macular edema (DME) is one of the major disease included in diabetic retinopathy. Early detection of a minor sign of DME is essential even if it appear without any external symptoms. Swelling in the macular region of retina which is also known as macular edema, is one of the major eye disease often leading to reduced capacity of visio (K.Sai Deepak *et al.*,2012) The first detectable abnormalities in eye are microaneurysms which represent local enlargements of the retinal capillaries. The ruptured microaneurysms can cause hemorrhages. After a period of time, hard exudates may appear. The hard exudates are lipid formations leaking from weakened blood vessels. Hard exudates represent the symptom of DME. In this article the detection of exudates and thereby severity level assessment is done by a two stage methodology in which first a decision is made about the presence or absence of HE in a given color fundus image. Once exudates presence is confirmed, assessment of the macular region for measuring the risk and classify the severity levels as severe, moderate, normal (Anitha Mohan *et al.*,2006)

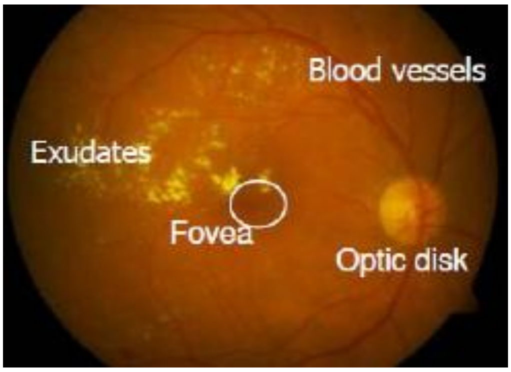


**Fig.1** Fundus image with exudates

Automated screening techniques for exudates detection have great significance in saving cost, time, labour and accuracy. Patients in rural areas are fundamentally harder to reach than in urban environments. So by conducting medical camp easy detection of DME can possible. Manual detection of exudates by ophthalmologists is time consuming and may cause error in result. Image processing techniques for exudates detection can help in extracting the location and size of exudates in the retinal images. In color fundus images they appear as yellow white deposits in Fig.1.Therefore, in this work, we propose an accurate method for detection and assessment of DME also glaucoma detection is done.

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## 2. Methodology

An algorithm was written for automatically detecting optic disc, fovea, ROI, motion pattern and exudates as part of DME detection from retinal images. Exudates detection faces some of problems that effect on the efficiency of any detecting algorithm. One of the major problems faces exudates detection is the color similarity between optic disc and exudates.

### *2.1 Image preprocessing*

This involves obtaining an gray image from fundus image,background normalization, contrast enhancement and image binarization. First the image is coverted to grayscale. Fundus image contains more red components ,so from the grayscale extract red channel and used for further processing. The normal fundus photographs, taken from camera for the diagnostic processes contain noise. If the detection is made with these images may lead to faulty results. Hence to improve the image quality, insufficient contrast between the exudates and the image background pixels and to remove the noises present in the input fundus images we done the filtering operation (Huiqi *et.al*.,2004).This stage that involves a number of steps, creates a flat disk-shaped structuring element ,to remove noise top-hat filtering is done, enhance the image contrast by histogram equalization.

### *2.1 Localization and masking of the optic disc*

The optic disc(OD) and exudates have similar characteristics that both of them appears as same intensity level in fundus image i.e they are found as bright yellowish. Therefore, before searching for exudates based on their yellow color, generate an algorithm is for automatic detection of the optic disc to eliminate this OD, yet it has similar structure. The localization of the optic disc performs and placing a rectangular mask within particular region of the retina is done (T.Walter *et.al*.,2001)

1) The detection of the optic disc

- First convert the image to binary
- Optic disc is detected and localized with the aid of regionprops function, finding area and centroid of each regions and determine the largest one, which corresponds to optic disk.
- Find the bounding box and mask the optic disk

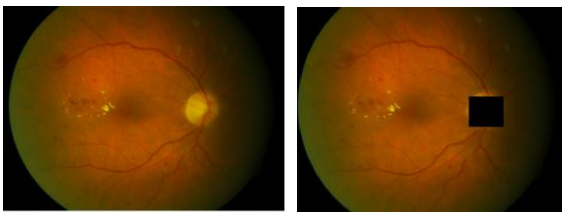

**Fig .2** Input image and OD masking

### *2.3 Localization of the fovea*

Macula is the middle part of eye appears darker in color. The fovea lies at the center of the macula that is used for fine vision. The candidate region of fovea is defined as an area of circle (Praveenkumar, 2011).After detecting the fovea it is highlighted in the main Fundus image. Hard exudates may be observed as the main indication of DME. The easiest and most effective way to diagnose macular edema is to detect hard exudates, which are usually associated with macular edema. It is the darkest point, but sometimes brighter due to the presence of lesions. Fovea localization is important in determining severity of DME.

1) The detection of the fovea

- Take the histogram equalization of gray scale of originalone
- Take the histogram equalization of filtered red components
- Subtract the filtered image from gray scale
- Convert the resulting image to binary
- Take the compliment of that image
- Then take the maximum area, which represents fovea

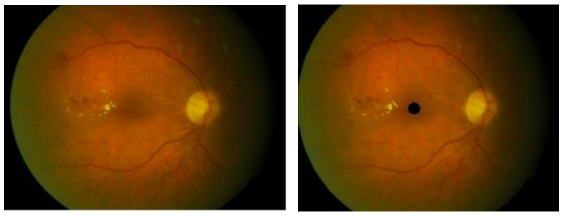

**Fig.3** Input image and detection of fovea

### *2.4 Region of Interest Extraction*

Then the image is analyzed which consists of exudates alone and further we calculate the region of interest(ROI) i.e. where the exudates are present in the image and make the fovea as the center of ROI. The images acquired for DME detection is analysed based on macular region. The region within this circle is the desired ROI. The centre of macula is automatically detected by finding new center from the centriod of fovea using mathematical polar coordinate concepts also applying a specific new radius and extract the specified ROI.

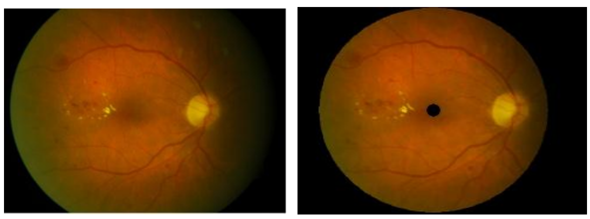

**Fig.4** Input image and ROI detection

*2.5 Detection of exudates*

Exudates are primary symptoms of DR and occur when leakages are formed in blood vessels. Exudates are small yellowish patches, having irregular shape, thus automatic exudate detection is a difficult task. We first find the candidate regions; these are regions that possibly contain exudates. Regions that contain exudates are characterized by a high contrast and a high grey level. In order to obtain the whole candidate regions rather than their borders, we fill the holes by reconstructing the image from its borders (Thomas Wlter, 2002).The suitable threshold is chosen in a very tolerant manner, i.e., we get the regions containing some exudates, but we also get some false positives. The papillary region and some other areas that are characterized by a sufficiently high grey level variation due to illumination changes in the image. Finally, we have to remove the candidate region that results from the optic disc. In order to find the contours of the exudates and to distinguish them from bright well contrasted regions that are still present in the candidate region. The final result is obtained by applying a simple threshold operation to the difference between the original image and the reconstructed image.

*2.6 Generation of motion patterns*

The creation of a motion pattern is motivated by the effect of motion on biological/computer visual system. These systems represent a scene as a set of spatially sampled intensities or an image. When an object in a scene moves at a high speed, it usually leaves a smearing pattern in the captured mage. We argue that there is much information about the scene in the smear pattern and propose to use it to represent an image. We do this by simulating this operation in a single image by inducing motion. Here motion is induced in a given image to generate a sequence of images. These are combined by applying a function to coalesce the intensities at each sensor location to give rise to a motion pattern (K.Sai Deepak *et al*.,2012).

A motion pattern for is derived as follows, Let the given ROI be denoted as intermediate motion pattern (IMP).

$MP = f(GN(I(r)))$

where r denotes a pixel location, GN is a transformation representing the induced motion which is assumed to be rigid. Practically speaking, GN generates N transformed images which are combined using to coalesce function. Here, GN(I) is expressed as follows:

$GN(I) = R\,\theta\, n\,(I)$

R is a rotation matrix. The rotation angle $\theta n = n\theta_0$with n=0,1,2......N; $\theta_0$ is the rotation step. Thus is a set of rotated versions of the given and the total number of rotated images. The transformation function is applied to generate a sequence of images which are rotated versions. The spatial extent of smearing of intensities depends on the maximum rotation whereas the sampling rate at each location is directly related to the size of each rotation step. The motion pattern IMP is obtained by using the union operation as the coalescing function. The choice of function should ideally depend to enhance the HE by increasing the extent of the smear caused by it in the motion pattern and increase the homogeneity of retinal background. This function can be Mean and Maximum. In this work we used maximum function, defined as

$MAX = \max(R\,\theta\, I(r))$

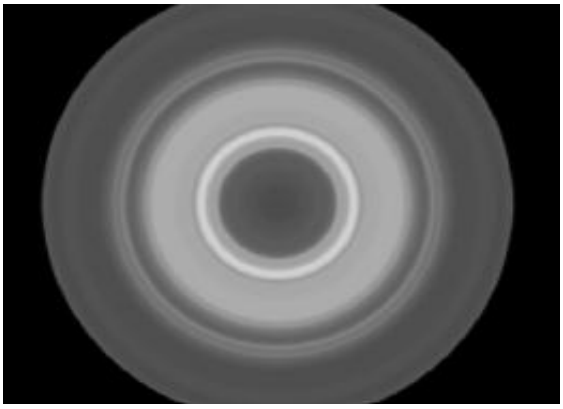

**Fig.5:** Motion pattern generation

*2.7 Determining the Severity of Macular Edema*

Assessing the severity of macular edema is the next step. HE within macular region indicates high risk for DME, requiring immediate attention. The macula in a normal image is relatively darker than other regions in the fundus image and is characterized by rotational symmetry. We use this symmetry information to establish the risk of exhibiting edema good degree of symmetry is taken to indicate the abnormality is not inside macula and hence it is declared as a moderate case. Asymmetry of the macula on the other hand implies abnormality is within the macula and hence the case is deemed severe. The proximity of detected exudates is checked for disease severity level assessment.

## 3. Glaucoma Detection

This paper also proposes a method for the detection of glaucoma using fundus image which mainly affects the optic disc by increasing the cup size is proposed. Glaucoma is an eye disease that threatens the eyesight of the patients (J.Liu *et.al*.,2009).

The neuroretinal rim around the optic disc (OD) is the most important region for glaucoma detection (Leater *et.al*.,2007)As the optic cup (OC) grows, the neuroretinal rim located between the edge of the OD and the OC which contains optic nerve fibers becomes smaller in area.

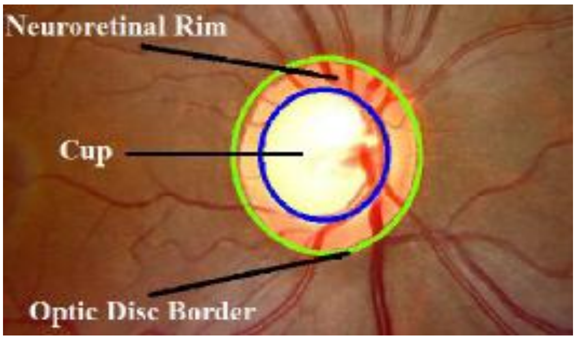


**Fig.6**: Optic disc structure

If the neuroretinal rim is too thin, vision will be deteriorated. Thus, quantitative analysis of the optic disc cupping can be used to evaluate the progression of glaucoma (J.Liu *et.al.*,2011) As more and more optic nerve fibers die, the OC becomes larger with respect to the OD, which corresponds to an increased CDR value. The ratio of the optic cup to disc (CDR) in retinal fundus images is one of the primary physiological parameter for the diagnosis of glaucoma. For a normal subject, the CDR value is typically around 0.2 to 0.3. Typically, subjects with CDR value greater than 0.6 or 0.7 are suspected of having glaucoma and further testing is often needed to make the diagnosis. The Kmeans clustering technique is recursively applied to extract the optic disc and optic cup region. Depends on CDR values disease severity level assessed. Region of Interest (ROI) based segmentation are used for the detection of disc. The K-means algorithm is an iterative technique that is used to partition the ROI image into K clusters. The ROI covers mainly the entire optic disc, optic cup and a small portion of other regions of the image. Cup-to-Disc ratio (CDR) measurement by calculating the vertical cup height divided by vertical disc height (Leater *et.al.*,2007).

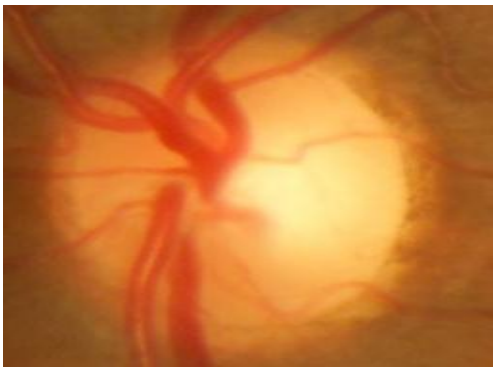

**Fig.6:** ROI extraction

## 4. Results and Discussion

A set of 30 images were captured under standard protocols obtained from eye care centers and the algorithm was tested using the training sample. The accuracy of the classification depends on better segmentation and brightness levels of the exudates and also on accurately extracting the parameters used for classification. The variations in image intensity level is analysed using Radon Transform. Here the edge detected output is analysed with each 30 degree upto 180 degree. In figure , the variations in each 30 degree is plotted as a line. We plot a graph of intensity level versus image size, indicates a great variation is appears near fovea in severe case condition.

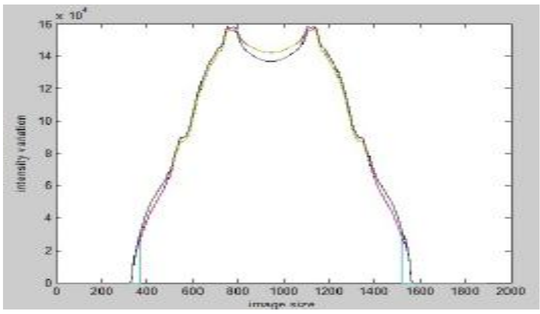

**Fig.7:** Radon space analysis-Severe condition

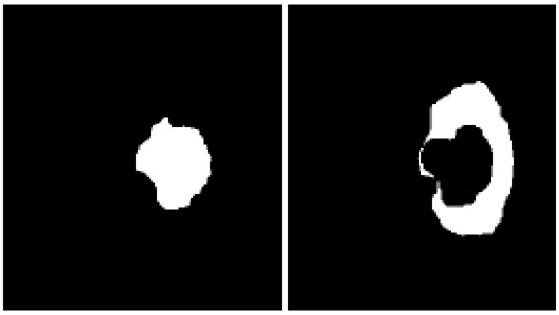

**Fig.8:** Optic cup and disc segmentation

Also the CDR value gives the information about glaucoma detection.

**Table 1:** Experimental results

| Total images checked | DME Detected | | | Glaucoma detected |
|---|---|---|---|---|
| 30 | Severe | Moderate | Normal | 4 |
| | 13 | 8 | 9 | |

## Conclusions

The important features in the fundus image of the retina such as optic disk, fovea, exudates are enhanced. This will help in detection of any kind of abnormalities in the eye, like DME and Glaucoma detection. The detected exudates can be used to identify the severity of the retinal decay. Image processing of color fundus images has the potential to play a major role in diagnosis of eye diseases. Efficient algorithms for the detection of the optic disc and retinal exudates have been presented. The algorithm is superior to the existing algorithms in terms of computational time and accuracy. In this work, the detection and classification of exudates in retinal fundus images was carried out and detection of glaucoma is done. The proposed method is simple and easier to implement when compared to conventional methods as it involves only logical operations on the RGB channels of the retinal fundus image. The proposed procedure seems to be useful for severity grading, and also for clinical interventions.

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