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Detection of Exudates for the Diagnosis of Diabetic Retinopathy

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ABSTRACT: Diabetes is a group of metabolic diseases in which a person has high blood sugar. Diabetic Retinopathy (DR) is caused by the abnormalities in the retina due to insufficient insulin in the body. Diabetic Retinopathy affects 80% of all patients who had diabetes for 10 years or more, which can also lead to vision loss. The most primitive sign of Diabetic Retinopathy is Exudates. Exudates in the retina are opacities that result from the escape of plasma and white blood cells from defective blood vessels. Detecting the exudates in an earlier stage can prevent the vision loss. In this paper, an automated algorithm has demonstrated to detect and localize the presence of exudates from low-contrast digital images of retinopathy patients with non-dilated pupils. In this method, first the retinal fundus image is pre-processed. Then, Mask Technique and Score Computation technique is used for segmenting the exudates in the retinal fundus images. This method does not require supervised learning which requires labeled set, may cause human error and it is time consuming process. It can effectively identify the lesions because exudates were clearly distinguished from optic disc and blood vessels. It helps the ophthalmologists apply proper treatments that might eliminate the disease or decrease the severity of it.

KEYWORDS: Diabetic Retinopathy, Exudates, Kirsch Edge detector, Mask Technique, Optic Disc, Score Computation.

1 INTRODUCTION

Diabetic eye disease is a leading cause of low vision and blindness in people of working age in industrialized countries. Approximately 33% of patients with diabetes have signs of diabetic retinopathy. DR is responsible for 1.8 million of the 37 million cases of blindness throughout the world However, according to medical test results, early detection and treatment may prevent more than 95% of the vision reductions that are observed in diabetic patients. DR is progressive dysfunction of the retinal blood vessels caused by chronic hyperglycaemia. Diabetic retinopathy is composed of a characteristic group of lesions found in the retina of individuals having had diabetes for several years.

Exudates are the primary and prevalent indication of diabetic retinopathy. Exudate is a fluid with a high content of protein and cellular debris which has escaped from blood vessels and had been deposited in tissues or on tissue surfaces of an eye. As it progresses, DR can significantly decrease visual acuity. The systematic screening process involves widening the pupil of an eye with chemical solution in order to identify the exudates manually. The various drugs used for mydriasis are amphetamine, tropic amide, atropine, mescaline, cocaine. In addition to diabetic retinopathy, the drugs used for screening process also affect the patients' eye sight. Fig.1.a. shows normal retinal fundus image and Fig.1.b. shows the image containing exudates.

(a)

(b)

Fig. 1. Retinal Images: (a) Normal Fundus image (b) Image showing Exudates

Li Tang et. al. [1] suggested new splat feature classification method to detect hemorrhages. The features were color, spatial location, interactions with neighboring splats, and shape and texture information. It can be obtained by dividing the image into number of segments. Finally, optimal subset of splat features is selected by wrapper approach. Istvan Lazar and Andras Hajdu [2] proposed novel method for detecting the Microaneurysms using directional cross-section profiles of an image. The statistical measures of the feature set such as size, height, and shape of every profile is used in a naïve Bayes classification to eliminate fake candidates. The binary image was obtained at the output side. Balint Antal and Andras Hajdu [3] suggested novel method for identifying the microaneurysms by considering the output of multiple classifiers. It can be detected by improving pre-processed methods and candidate extractors. K. Sai Deepak and J. Sivaswamy [4] introduced motion pattern technique for detecting macular edema. Gaussian and PCA Data Description classifiers were used to extract the exudates. Symmetry measure is used for assessing the severity level.

L. Giancardo et. al. [5] used multiple views of the retinal fundus images for detection and quantitative measurement of the disease. In, Pre-processing stage, the dark microstructures of the macula was enhanced. All the available views were registered and dense pyramidal optical flow is calculated to build a naive height map of the macula. K. Ram et. al. [6] proposed successive clutter rejection method for detecting the Microaneurysyms (MAs). This method has two clutter rejection stages to classify MA from Non-MA. C. Agurto et. al. [7] developed the technique for detection of DR by using instantaneous amplitude and instantaneous frequency characteristics of an image. Keerthi Ram and Jayanthi Sivaswamy [8] proposed Multi-space clustering method to distinguish hard and soft exudates. Alireza Osare et. al. [9] used pattern recognition with machine learning techniques to analyze diabetic retinal images. Akara sopharak [10] used FCM clustering technique for detecting the exudate pixels.

Several algorithms have been developed to automatically identify the exudates which eliminate the needs of human experts. In this project, Mask technique and Score Computation technique is used for classify the exudates from the non-exudates pixels in the retinal images. The fragmented result is then used for validating the severity of the lesions. The demonstrated method is prompt and robust method that can attain high sensitivity and specificity.

2 MATERIALS AND METHODS

2.1.1 IMAGE ACQUISITION

The color fundus images used in this paper were obtained from largest, publicly available dataset MESSIDOR databases. Working images are JPEG format with a size of 2196 X 1958 at 24 bits. These databases includes binary mask for every fundus images.

2.1.2 PRE PROCESSING

The color image was converted into HSV image. The fundus image may having non-uniform illumination, intensity variation and noises. To reduce the effect of such problems, pre-processing was performed on the intensity component of an image. The intensity component of an image was used here to differentiate the bright lesion from other features of the retinal image. Median filter was applied on the image that reduces the blurring of edges of an image and significantly eliminates impulse noise. It suppresses noise without reducing the image sharpness. Contrast enhancement technique evens out the distribution of used gray values and thus makes hidden features of the image more visible. The original input image and preprocessed image are shown in fig.3 and fig.4.

Fig.3. Original Image

Fig. 4. Pre-Processed Image

2.1.3 Mask Technique

Optic disc detection is a primary step in automated screening systems for diabetic retinopathy. The OD often serves as a landmark for other fundus features; such as the quite constant distance between the OD and the macula-center (fovea) which can be used as a priori knowledge to help estimating the location of the macula. The OD is the brightest feature of the normal fundus, and it has approximately a circular or vertically slightly oval (elliptical) shape. In colored fundus images, the OD appears as a bright yellowish or white region. In our project, Exudates recognition is the main purpose, it is necessary to remove the optic disc prior to the process. Because OD appears with similar intensity, color and contrast to other features on the retinal image. The optic disc is characterized by the largest high contrast among circular shape areas. While vessels also appear with high contrast, the size of the area is much smaller. So Optic disc is detected and masked. The masked image is shown in fig.5. Mask technique aims at labeling pixels belonging to the Region of Interest (ROI) in the entire image. Pixels outside that ROI are those belonging to the dark surrounding region in the image. Masking process includes the following steps:

- Blur the original image,
- Subtract the blurred image from the original image which is called as mask,
- Add the mask to the original image

Fig.5. Masked Image

2.1.4 Score Computation Technique

In our suggested method, exudates were segmented using score computation technique. It can be performed by connected component labeling method which is based on neighborhood approach. The goal of the connected component analysis is to detect the large sized connected foreground region in an image. The pixels that are collectively connected can be clustered into changing or moving objects by analyzing their connectivity. In binary image analysis, the object is extracted using the connected component labeling operation, which consist of assigning a unique label to each maximally connected foreground region of pixels.

The algorithm starts with finding its non-background neighbors. If none of the neighbors is labeled yet, label count is incremented and set it to the current pixel, and also set the label's parent to itself. Move on to the next pixel, this one has a neighbor which is already labeled and assigns the pixel's label to that of the neighbor. This process is continued until none of the neighbors of this pixel is labeled. The label count is incremented and assigns it to the pixel and again setting its parent to itself. When neighbors have different labels, any one of the labels has chosen and set it to the current pixel. By this approach, brighter lesions were obtained which shows both exudates and blood vessel.

2.1.5 Removal of Blood Vessel

It is necessary to remove the regions that share the exudates with blood vessels. So, contour detection is significant process in this method. Edge detection algorithm was used to remove the blood vessels. Edge detection is the most familiar approach for identifying significant discontinuities in intensity values. The edge detected image is shown in fig.6

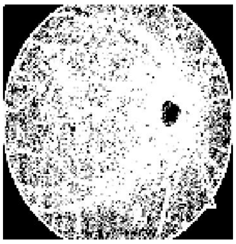

Fig.6. Edge Detected Image

Kirsch edge detection is used to remove the blood vessels by using threshold values. The Kirsch operator is a non-linear edge detector that finds the maximum edge strength in a few predetermined directions. The kirsch edge detector not only defines the presence of edges but also it determines the direction in which the edge moves. The masks of this Kirsch technique are defined by considering a single mask and rotating it to eight main compass directions such as North, Northwest, West, Southwest, South, Southeast, East and Northeast. Blood vessel removed image is shown in fig.7

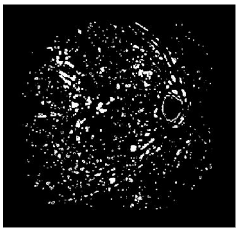

Fig.7. Blood Vessel Removed Image

The Kirsch edge detection algorithm uses a 3×3 table of pixels to store a pixel and its neighbors while calculating the derivatives. The 3×3 table of pixels is called a convolution table, because it moves across the image in a convolution-style algorithm. Kirsch edges try to capture the external edges of the lesion candidate. The average edge outputs under each lesion cluster are calculated and assigned to the lesion in its entirety. Finally, this algorithm provides segmented image which can clearly distinguish the exudates portion from the non-exudates pixels. The resultant image shown in fig.8 was exposed in color which clearly indicates the exudates pixels in the segmented retinal image.

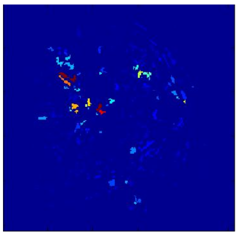

Fig.8. Segmented Image Showing Exudates

3 Conclusions

The method present in this project is a prompt and efficient method for Exudates detection. The proposed system is a very simple technique which enables the ophthalmologists to detect exudates with very less inspection time. This segmented image shows the location of exudates confirming the disease diabetic retinopathy

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