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A Survey on Hard Exudates Detection and Segmentation

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Abstract-diabetic macular edema (dme) is an advanced symptom diabetic retinopathy. it causes damage to retina and may lead to complete or partial vision loss. exudates are the primary indication of diabetic retinopathy. in this paper, different techniques were presented which is used for detecting the hard exudates. the segmentation of hard exudates is also achieved.

Keywords - Diabetic Retinopathy, Hard Exudates detection, Neural Network, Fuzzy C-means and K-means Clustering Algorithm.

I.INTRODUCTION

Diabetic retinopathy (DR) is the result of micro vascular retinal changes triggered by diabetes that can lead to a total loss of vision if not treated in a timely manner. Diabetic Retinopathy frequently has no early warning signs. It is the most common disease causing blindness among people aged 30-69 years. In case of diabetic retinopathy retinal blood vessels get damaged, protein and fat based particles gets leaked out of the damaged blood vessels and are deposited in the intra-retinal space. They are usually seen as whitish marks of various shapes and are known as exudates. Even macular edema, which may cause vision loss more quick, may not have any warning signs for same time. As new blood vessels form at the back of eye as a part of Proliferate Diabetic Retinopathy (PDR), they can bleed (hemorrhage) and blur vision. In severe cases, a person will only be able to tell light from dark in that eye. Normally, diabetic retinopathy is classified into
two main stages, namely non proliferative diabetes retinopathy (NPDR) which can be classified to mild,
moderate or severe stages and proliferative diabetes retinopathy (PDR) is the advanced stage whereby signals are sent by the retina to the body for the lack of blood supply and this triggered the growth of new blood vessels.

Hard exudates

It is small white or yellowish white deposits with sharp margins. Frequently, hard exudates appear as waxy, shiny, or lustrous. They are situated in the outer layers of the retina, interior to the retinal vessels. They can be set as individual dots, concurrent patches, sheets, or in rings or crescents surrounding zones of retinal edema or groups of micro aneurysms. Exudates are irregularly deposited along retinal veins.

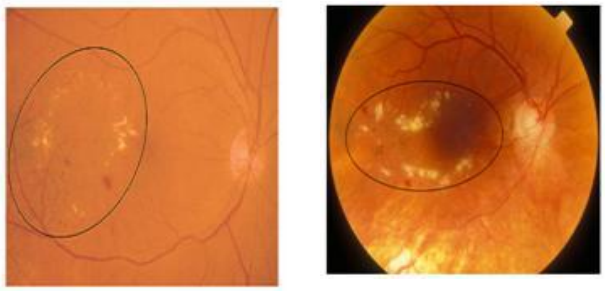

Fig: 1 Moderate and severe hard exudates

Soft Exudates

In severe stages of Diabetic Retinopathy, certain spots are commonly known as cotton wool spots are recognized. The retinal pre capillary arterioles supplying blood to the nerve fiber layer are clogged and associatively the local nerve fiber axons get enlarged; thereby creating a cotton wool spot.

Fig: 2 Soft Exudates

II.METHODS

An automatic method to detect the presence of exudates in earlier is preprocessing. It is used to reduce the noises by using color space conversion, median filtering and histogram equalization.

Image Processing

Differences in luminosity, contrast and brightness inside retinal images make it difficult to extract retinal features and make a difference of exudates from other bright features in images. Hence Image Preprocessing is required to eliminate noise present in the image equalization of the irregular illumination related with retinal images.

HSI color space conversion

An RGB image is an M x N x 3 array of color pixels, where each color pixel is a triplet equivalent to red, green and blue components of RGB image at specific particular location. As a first step of preprocessing the original RGB image is changed to HSI (hue, saturation and intensity) color space. The HSI color space is generally used color model for image-processing applications because it represents color correspondingly how the human eye senses colors. The other motivation for selecting the HSI color space is that the Intensity matrix of the image can be separated from other components such as hue and saturation, so that important information needed for the diagnosis of exudates, enclosed in the intensity matrix alone such as intensity, standard deviation of strength, distance between optic disk mean pixel value and exudates and non-exudates pixels can be extracted. Hue is a color attribute that describes a pure color; Saturation gives a measure of the degree which the amount of white light mixed with the hue.

Median Filter

Median filtering is an efficient method for overcoming the isolated noise without blurring the sharp edges. It changes the pixels by the median of all pixels in the neighborhood of small sliding window. Median filter is a very good choice for removing the noises such as salt and pepper noise and also horizontal scanning artifact.

Adaptive Histogram Equalization

The fundus images usually have irregular illumination with areas at the middle of the image brighter when compared to sides and the brightness decreases as distance from the center of the image increases. To accomplish uniform illumination adaptive histogram equalization is used so that the dark area in the input image becomes brighter in the output image bright area that was highly illuminated remains or reduces so that the image has uniform illumination.

Optic Disk Elimination

Since the optic disk has more or less same characteristics and bright intensity as the hard exudates, the optic disk is detected and eliminated to reduce false positives. Initially, the area of interest specifically the optic disk is selected using Region of interest from the preprocessed intensity image I which is named as I1. This is achieved by using roipoly function presented in matlab. Further binary image of size 256x256 with all ones is taken as I2. Image I1 is subtracted from image I2 to get image I3. The image I3 is finally multiplied with preprocessed Intensity image I, which results in elimination of optic disk.

III.DETECTION OF HARD EXUDATES

Hard exudates can be detected by using several approaches. Some of the approaches are Top-Down and Bottom-Up approach, hybrid approach and Neural Network Based Detection.

Top-Down and Bottom-Up Approach in lesion detection

In diabetic macular edema lesions are deposited at retinal areas and which can lead to vision loss. Regular screening is the mainly efficient way of reducing the preventable eye damages. There are two kinds of lesions in the diabetic fundus images. One is bright lesion that includes exudates and cotton wool spots.

The other is dark lesion consists of hemorrhages. Exudates are yellow white lesions with relatively different margins. They are lipid deposits inside the body of the retina. Cotton wool spots are whitish patches that have no clear margins. They are not real exudates but degenerating nerve fibers. Hemorrhages have “dot” and “blot” configurations in the background diabetic retinopathy with their color related to the blood vessels.

In this approach the detection is done based on different properties of bright lesions and dark lesions, bottom-up and top down approaches are applied respectively to deal with the main difficulties in lesions detection such as inhomogeneous illumination. In bright lesion recognition, a three-stage, bottom

up approach is applied. Local contrast enhancement depends on the mean and variance of the intensity inside the local area

Hybrid Approach

The purpose of Hybrid approach is to detect the hard exudates. This Hybrid approach consists of three stages: preprocessing, post processing and clustering.

Pre processing

The main purpose of preprocessing is to eliminate unwanted details from an image and make the image apt for applying next step. Here, Input image is initially resized to fixed size of 256×256. Green channel is extracted from resized image and then morphological dilation is applied by using disk shape structuring element.

Clustering

Once the image is dilated, clustering algorithm is applied on image to get Hard Exudates. Clustering is performed individually in each feature space, and the obtained labels are combined in a special manner to yield exudates segments.

Post processing

Once clustering Algorithm is applied to Dilated Image, Hard Exudates Regions are obtained in any of the one cluster from *k* clusters. It has been seen that normally Hard Exudates and Optic disk are of same color, brightness and contrast.

So, sometimes optic disk is mistaken and must be removed from the Hard Exudates result obtained after applying a clustering algorithm to obtain accurate Hard Exudates. Here, Circular Hough Transform is applied to the result obtained by applying a clustering algorithm for detecting optic disk. Once the optic disk is detected it is eliminated and the Hard Exudates result is obtained.

Neural network Based Detection

Neural Network is an information-processing model that is inspired by the way biological nervous systems such as the brain process information. Neural Networks (NNs) are used to classify the retinal exudates. The three different types of Neural Networks to detect Exudates in retinal images: Multi Layer Perceptron (MLP), radial basis function (RBF) networks and SVMs.

Multi layer Perceptron (MLP)

Multilayer feed-forward networks, like MLPs, are an important group of Neural Networks that can represent nonlinear functional mappings between a set of input variables and a set of output variables. A MLP with enough units in a single unknown layer can approximate any function, provided the activation function of the neurons satisfies some common constraints.

From these considerations, MLP with one hidden layer is used, for which the optimum number of hidden neurons was experimentally determined. The problem of training a Neural Network can be formulated in terms of the minimization of an error function.

Radial Basis Function (RBF)

RBF is also a universal approximator and its architectural model comprises three layers. First is the input layer which receives the feature vector and has many neurons as the length of this vector. The only hidden layer in the network performs a nonlinear transformation from the input space into a high dimensional space, where the patterns are more probable to be linearly separate. The output layer is linear, and supplies the response of the network to the activation pattern.

Native RBFs require as many hidden neurons as the available training points. This is computationally complex and may lead to poor generalization ability. To achieve this task, orthogonal least squares algorithm is applied. The optimum spread and number of radial basis functions were experimentally determined. The output threshold was set to 0 because the output of RBF is positive for exudates negative for non-exudates.

Support Vector Machine

Like the previous approaches, Support Vector Machines can estimate any function. As in Radial Basis Functions, the input space is mapped into a high dimensional feature space. Then, the hyperplane that maximizes the margin of separation between classes is constructed. The points that lie closest to the decision surface is known as support vectors and directly affect its location. When the classes are nonseparable, the optimal hyperplane is the one in which it minimizes the probability of classification error. In this case, the problem can be solved using the method of Lagrange multipliers.

IV.AN APPROACH FOR HARD EXUDATES SEGMENTATION

Hard exudates are responsible for exudative maculopathy was detected using two levels of segmentation for improved accuracy. The coarse segmentation of exudates that was achieved using K-Means clustering algorithm and Fuzzy C means algorithm provided a better initial coarse segmentation. Fine segmentation using morphological reconstruction technique classified the correct exudates pixels from the background. The optic disc which has almost the same intensity as exudates is masked during the exudates detection process to avoid false positives.

Coarse Segmentation of Hard Exudates

Even though hard exudates are considered as bright regions in a retinal image, there are various factors that affect the segmentation of exudates using a single global threshold. For instance, the contrast enhancement algorithm not only enhances the brightness of lesions but also increases the brightness of some pixels. These pixels will be wrongly recognized as lesion pixels. There is also a possibility that segmented image may contain lesions like cotton wools, drusen and pixels surrounding the optic disc. Therefore to classify the segmented region into exudates or non exudates, K-Means clustering and Fuzzy C-Means algorithm is employed.

k- means clustering algorithm

The *k*-means clustering algorithm is generally used in computer vision as a form of image segmentation. The outcomes of the segmentation are used to help border detection and object recognition. In this algorithm, the standard Euclidean distance is generally insufficient in forming the clusters. Alternatively, a weighted distance measure utilizing pixel coordinates, RGB pixel color or intensity, and image texture is usually used. The *k* means algorithm assigns each point to the cluster in which the center (also called centroid) is nearest

Fuzzy C means Algorithm

In non-fuzzy or hard clustering, data is separated into crisp clusters, where each data point belongs to accurately one cluster. In fuzzy clustering, the data points can belong to more than one cluster, and related with each of the points are membership grades that show the degree to which the data points belong to the dissimilar clusters

Fine Segmentation of Exudates

The segmentation of image by clustering can be results in number of candidate exudate regions. In order to properly classify the exudate pixels from the non exudate pixels, morphological image reconstruction technique is used. It is an iterative method that extracts regions of interest from an image by frequent dilation on two images, marker and mask.

Reconstruction Technique

The reconstruction algorithm is divided into three phases: preprocessing, registration and naïve-height-map reconstruction. First, the fundus images are enhanced to remove background information and reflections from the nerve fiber layer. Second, all images are rigidly registered by employing fiducial points independent of retina morphology. Finally, the naive height map is reconstructed exploiting the statistical distribution of a dense optical flow analysis between images.

V.CONCLUSION

An automated DR detection system is a very important need due to the growing up number of diabetic patients around the world. For this automated system, in this paper a number of algorithms are surveyed and different algorithms are found to give better results as far as exudate detection is concerned. From the various performance metrics Fuzzy C-Means algorithm detects exudates more accurately than other algorithms with a sensitivity of 92.08%, specificity of 99.52%, PPV of 86.66% and accuracy of 99.87% and also some lower amount of false positive regions are noticed.

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