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Detection of Diabetic Retinopathy by Texture Analysis of Fundus Images

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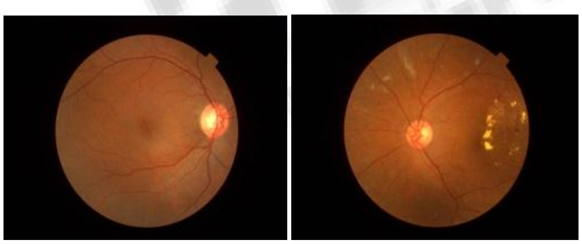
Abstract - **Medical analysis is one of the fastest growing fields where a lot of recordings of patients are analyzed. Many researchers finding new technologies to automate the way of detection of the disease. Diabetic Retinopathy is one of the complex diabetics which can cause vision loss. Diabetic Retinopathy is detected by the presence of microaneurysms and exudates in the color fundus image of the eye. This work examines the analyzing capabilities in the texture of color fundus images to differentiate between diseased and healthy images. Aiming this, the performance of Local Binary Patterns as a texture descriptor for retinal images has been explored. The performance of the proposed algorithm is analyzed using parameters like sensitivity, specificity, and accuracy.**

Keywords: **Color fundus images, Diabetic Retinopathy, Medical analysis, Microaneurysms, Local Binary Patterns**

I. INTRODUCTION

Across the nation, many people are affected by various diseases in which retinal disease is one among them. The prime targets are the diabetic patients leading to the diabetic eye disorders. This eye disorder may lead to blindness or partial vision loss. About five percent of the world is suffering from retinal disease. Diabetic retinopathy is one the causing visual impairment. Figure.1. gives color fundus images of Healthy and Diabetic Retinopathy (DR) images. Diabetic Retinopathy is frequently causing disease among retinal disease leading to vision loss. It microaneurysms (MA) and exudates are the signs of presence of DR.

Microaneurysms appear due to the local weakening of the walls of the blood vessels of the capillaries, causing them to swell. In addition to leaky blood, the vessels will also leak lipids and proteins causing small bright dots called exudates. Drusen is formed when few small regions of the retina become ischemic.



(a) (b)

Figure. 1. Color Fundus Image (a)Healthy image (b)DR image

A small portable device is used to visually examine patient's retina by Ophthalmologists called ophthalmoscope. The fundus images are the back-end image of the retina. These fundus images give the clear picture of the characteristic textures to detect the retinal disease.

The World Health Organization (WHO) evaluates that numerous people outwardly impeded far and wide according to the analysis made in 2010. The number of blind peoples are reduced and they are preventable and treatable [1]. Many examples exist where LBP method is used for feature extraction to detect the disease. It depends on taking the local variations around every pixel and relegating labels to various local patterns. From that point, the distribution of the labels is assessed and utilized as a part of classification stage. There are numerous cases of the accomplishment of LBP utilized to depict and classify textures in all areas [2]–[5] and medical field [6]–[9].

M. Heikkil et.al [5], presents the presence of appearance of an interest region can be well characterized by the distribution of its local features. The Scale Invariant Feature Transform (SIFT) descriptor which utilizes the gradient as the local feature is based on this thought. The changed version of the LBP feature called center-symmetric local binary pattern (CS-LBP) is utilized as the local feature in the

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SIFT method to join the characteristics of SIFT and LBP.

L. Nanni et. Al [9] concentrates on the utilization of image-based machine learning methods in medical fields. Specifically, we introduce few variants of Local Binary Patterns (LBP), which are broadly viewed the best accessible technique among texture descriptors. With the complete review of existing LBP variants, most remarkable methodologies, along with advantages and disadvantages, new trails utilizing LBP-based descriptors were accounting for. An arrangement of novel texture descriptors for the portrayal of biomedical images was proposed. The standard LBP operator is a gray-scale invariant texture measure. With help of considering distinctive states of neighborhood and different encodings for the assessment of gray-scale difference, variants are found. These arrangements of components are utilized in classification.

S. Zabihi et. al [10], local contrast enhancement of the color retinal image is achieved by multi-scale morphological algorithms. It enhances vessels in RGB color components, not only in one color component. LBP and spatial image processing are used for feature extraction process. At that point, MLP classifier sections the pixels into vessels and non-vessels. At last, post-processing is done for noise removing and smoothing. The proposed method is verified on the database DRIVE.

LBP have not been generally utilized. Best works that utilizes the LBP method on fundus images concentrates on the segmentation of the retinal vessels [10] instead of full diagnosis framework. A last segmentation of the exudates, optic disc, and blood vessels is required for feature extraction.

There are numerous cases of the accomplishment of LBP used to depict and classify textures in all and also in the case of medical field. However, regarding fundus image processing, LBP have not been broadly utilized. The best works that utilizes the LBP method on fundus images concentrates on the segmentation of the retinal vessels rather than on a full diagnosis system. Most MA finders handle the issue of classifying in the accompanying way: to begin with, the green channel of the fundus images is extricated and pre-processed to improve MA like characteristics. Our previous examine demonstrated that the low sensitivity of MA detectors originates from the candidate extractor part.

The disadvantage of this method was all MA-like objects are misclassified since it is difficult to separate from fragments of the vascular system or from certain eye feature. And manual lesion segmentation is tedious.

A method for manual lesion segmentation is tedious and automatic segmentation calculations will not be exact. Thus expelling the requirement for lesions segmentation can make the classification more powerful. The method is based on the texture analysis of the retina background by LBP and VAR values rely upon the radius of the neighborhood [5].

Just the pixels of the retina background are viewed as noteworthy for the texture analysis. The green channel component of the color fundus image is considered. Blood vessels and optic disk are detected using canny edge detection. The fundamental thing lies in finding for the execution of Local Binary Patterns (LBP) as a texture descriptor for retinal images.

The objectives of the proposed system are:

1) To enhance the input retinal images using preprocessing techniques.
2) Detect the blood vessels and Optic disk in the retina
3) Extract the texture features and Variance
4) To classify the retinal disease based on the texture features.

The proposed method is to design and develop an efficient methodology to diagnose DR disease using color fundus images. The pre-processing steps segment the vessel and optic disc and mask them retaining the abnormal brighter segments in the remaining portion of the region of interest. This paper looks at the abilities in the texture of fundus to separate healthy images and DR images. Variance and LBP features are generated and are used for the classification of the disease and its severity. The texture analysis of color fundus image (CFI) assists ophthalmologist's diagnosis by providing

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detailed features of optic disk, fovea and blood vessels also microaneurysms and hemorrhages for comprehensive analysis.

The rest of the paper is sorted out as, the materials and the method used is explained in section II, the methodology is described in section III, the results are given in section IV. Output and the future work are discussed in section V.

II.EASE OF USE

In this section, the details of the database and the method applied is explained

A. Selection of Database

Retinal imaging system helps ophthalmologists to diagnose the disease and to monitor the treatment processes. Conventionally, fundus images are obtained from expensive systems like fundus photography which are large table-top units and can only maintained by trained technicians. We have a various database that contains fundus images of healthy, DR disease like E-Ophtha, STARE, ARIA, Messidor etc. E-Optha contains 157 healthy images and 174 DR images. STARE database has 37 healthy images and 89 DR images. ARIA has 61 healthy image and 59 DR images. In this work, the database of fundus images used is E-Ophtha and fundus images collected from a hospital.

B. Local Binary Patterns (LBP)

The LBP operator was designed for texture description. It assigns a label for 3x3-neighborhood of each pixel with the center pixel value. The obtained binary string is turned to gray value to every pixel. Texture descriptor is obtained by the histogram of these labels which are assigned to each pixel.

LBP label for every pixel is calculated for the complete image. This label is accounted based on local neighborhood of that pixel implied with radius of 1 and samples considered are 8. Then the label found is based on gray value of the center pixel and neighboring pixel. The binary string is found as shown in Figure.2.

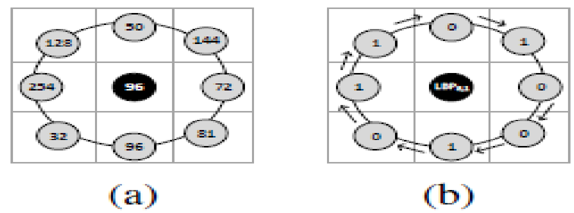

Figure.2. Computation of LBP value to each pixel of CFI (a) Gray values of a circular neighborhood of R=1,P=8. (b) Converting to binary values from thresholding between the gray value of neighborhood and center pixel value.

From the above Figure.2, the binary string in the direction shown is 00101101. Individually, the LBP label is found as follows

LBP8,1=0*20+0*21+1*22+0*23+1*24+1*25+0*26+1*27 = 180.

The estimation of an LBP label is found for each pixel by adding the binary string weighted with powers of two given by equation (1).

$$LBP_{P,R}=\sum_{p=0}^{P-1} s(g_p-g_c)\cdot 2^p, \quad s(x)=\begin{cases}1, & if\ x\geq 0\\ 0, & if\ x<0\end{cases} \qquad (1)$$

Where gp and gc are the gray values of the neighborhood and focal pixel, respectively. It is regular to incorporate a contrast measure by characterizing the rotational invariant local variance with LBP as taken after:

$$VAR_{P,R}=\frac{1}{P}\sum_{p=0}^{P-1}(g_p-\mu)^2, \quad \mu=\frac{1}{P}\sum_{p=0}^{P-1} g_p \qquad (2)$$

III. METHODOLOGY

In this section, the detail of the method is explained. The steps of the method are depicted in the outline as given in the Figure.3.

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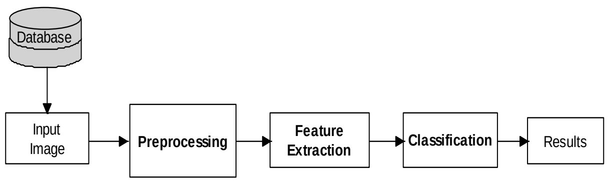

Figure 3: Outline of the proposed method.

The steps depicted in the outline are as given below.

A. Pre-processing

The preprocessing involves obtaining the green component of an image from CFI. Image enhancement can be done by using Adaptive histogram technique. Firstly, we have to find optic disc and the vascular network. The disease is recognized by the presence of microaneurysms and exudates in fovea region. So blood vessels and optic disk can be masked. The edge detection is done by canny edge detection method. The detailed steps of preprocessing are illustrated in Figure. 4.

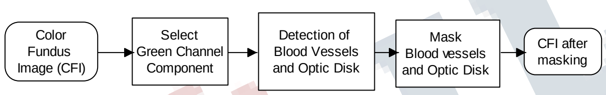

Figure 4: Detailed steps in preprocessing.

The results of this step are shown in Figure.5.

Figure 5: Output of preprocessing stage (a) healthy image (b) image after applying canny edge detection

B. Feature Extraction

The important objects are considered for feature extraction in an image. The feature extraction is done by Local Binary patterns (LBP) and Variance (VAR) methods. These methods are applied to the masked image obtained from preprocessing stage. The LBP and VAR operators are to be utilized to portray the texture of the retina background ascertaining for every pixel of the fundus images. The LBP and VAR values comparing to pixel positions of the optic disc, vessels or outside the fundus are not considered. The statistical values are extricated from LBP and VAR images to consider for classification. These are mean, median, standard deviation, entropy, skewness, and kurtosis. These six features from LBP and VAR gives rise to 12 feature set for each image. The images obtained with the pixel value replaced by calculated LBP and VAR values are as shown in below Figure.6.

Figure 6: Results (a) LBP image (b) VAR image.

C. Classification

The texture and variance features are used to classify the normal or abnormal state of the image. The method used here is Support vector machine (SVM). It is the broadly utilized method for solving classification problems. The main thing is to find the hyperplane that separates a images into one of the two previously mentioned classes. Then it is depicted using training data to find the hyperplane parameters so that the distance to any training sample is increased. Larger margin better is the generalization of the classifier.

The set of images are divided as train images, validation images and test images on using external cross validation. Based on weights and bias value, using labels of images from training dataset, classifier is trained. The test image undergoes preprocessing, feature extraction methods then classified as either healthy or DR image from trained classifier. This is depicted in below Figure.7.

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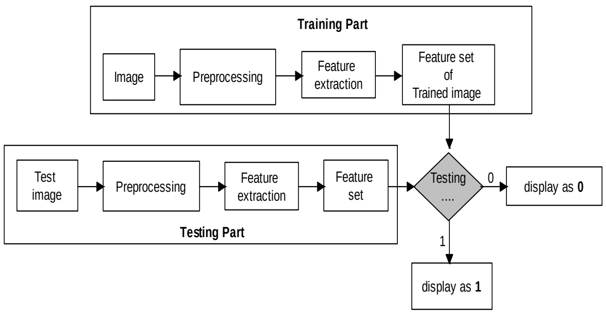

Figure 7: A detailed block diagram of Classification part.

The feature set that is stored is the basis for classification of test images. The output is displayed as 0 for healthy image and 1 for DR image.

IV. RESULTS

The proposed method is to design and develop an efficient methodology to diagnose retinal disease using color fundus images. The pre-processing segments the vessel and optic disc and masks them retaining the abnormal brighter segments in the remaining portion of the region of interest. The variance and LBP features help to detect and classify the disease.

The method is tested with LBP, VAR and LBP+VAR method as feature extraction by which we consider 6, 6, 12 features respectively. The test images given must be classified and notified as healthy image indicating 0 and DR image as 1. The sensitivity and specificity are less when LBP or VAR method is used. For set of 135 images given to a classifier, the obtained sensitivity and specificity are 0.86 and 0.847 are respectively, when 12 features are considered from combination of LBP and VAR methods.

CONCLUSION

Medical diagnosis is to be automated for attempting to detect the disease and to conclude by several processes. Presently, technicians in diagnostic center determine the presence of the disease. Here, software is implemented for diagnosis purpose. Doctors can make second opinion on the obtained result. Presently, technicians in diagnostic center determine the presence of the disease. The method proposed for pre-processing procedure is to improve the contrast of input image and feature extraction technique is applied. Finally the output image is classified into either of the classes. An average sensitivity and higher specificity were achieved. The obtained result predicts that proposed method is strong algorithm to describe retinal texture and utilized to diagnose the retinal disease. The future work includes testing the algorithm for large database and applied for real-time analysis obtaining sensitivity and specificity of 1. The method is to be extended for the screening of different diseases including grading of respective disease

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