Microaneurysms and Hemorrhages Detection in DR using Compresed Sensing

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Abstract— *Diabetic Retinopathy is a most common diabetic eye disease which is a leading cause of blindness. Diabetic Retinopathy is a disease in which the retinal blood vessels swell and it may even leak. This damages the retina of the eye and may lead to vision loss if the level of diabetes is very high. The method proposed in this paper for detection of Diabetic Retinopathy disease level emphasizes on determination of two important types of Diabetic Retinopathy(DR); Hemorrhages(HEM) and Microaneurysm (MA). These types can be extracted using fundus images of patients and processing these fundus images through an appropriate image processing technique called Compressed Sensing(CS), which helps in extraction of dark lesions or lesions from less contrast image. Based on the presence of these types and their amount in the fundus image will determine the level of Diabetic Retinopathy in patients and severity is classified using Convolution Neural Network classifier.*

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Keywords—*Diabetic Retinopathy, microaneurysms, hemorrhages, funus images,comppressed sensing,convolution neural network classiir.*

I. Introduction

The human eye is an organ which gives a sense of sight. Lots of people in rural and semi urban area are suffers from eye diseases such as glaucoma, Diabetic retinopathy, macular degradation. The early detection and treatment of retinal eye helps to control vision loss. Conventionally, retinal diseases identification techniques are based on manual observations which consume time. Diabetic Retinopathy is a chronic disease ,which if not detected in early stages can lead to permanent blindness. DR is the ocular disorder which leads to permanent blindness especially in aged humans. As the disorder is irreversible it is important to detect it in its early stages. The medical techniques used by ophthalmologists to screen glaucoma are time consuming and requires special skill and equipment's. Hence there is a need for computer based automatic systems which make screening of DR easier and faster. A digital fundus image is used for screening of DR as it consumes less time, have higher accuracy and requires no skilled force. As compared to other complex devices, digital fundus camera is more economical and is frequently used in basic eye examination. Detection of optic disk is essential in developing automatic diagnosis systems and its segmentation is a crucial and a vital step.

Proposed system has two parts feature enhancement at the initial stage and training at the final stage of classification. RGB images are collected using a fundus camera., The green component are extracted from RGB image for further processing. First step is pre processing in which the noise is removed, blood vessels are extracted, and enhance the image using CLAHE technique. Next is compressed sensing algorithm which uses an iterative method in order to enhance the dark lesions in diabetic retinopathy by reducing mean square error. And then segmentation which follows thresholding based segmentation method. Segmentation is followed by feature extraction where features of region of interests are extracted using GLCM. And finally Convolution Neural Network classifier with the help of already trained images classifies the input image and decision is made whether the candidate is suffering from microaneurysm or hemorrhage.

The project is designed with the fundamental knowledge in digital image processing, basics of statistics, Classifiers, convolution neural network and fundamental mathematics involving matrices. The program is developed using Math works MATLAB software, which it is presented in a Graphical User Interface. The concepts of Digital Imaging are covered in the following Digital Image, Image Preprocessing, Image Analysis and Classification

II. PROPOSED SYSTEM

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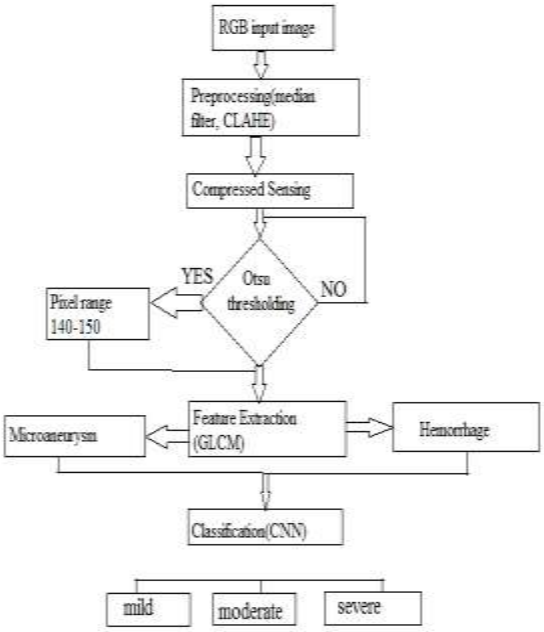

Fig 1: Flowchart of proposed system

A. Pre-processing

Median filtering is a nonlinear method used to remove noise from images. The median filter works by moving through the image pixel by pixel, replacing each value with the median value of neighbouring pixels, which slides, pixel by pixel over the entire image. The median is calculated by first sorting all the pixel values from the window into numerical order, and then replacing the pixel being considered with the middle (median) pixel value. It is used to remove salt and pepper noise.

Adaptive histogram equalization (AHE) is a automated image processing technique used to improve contrast in images.It is therefore suitable for improving the local contrast and enhancing the definitions of edges in each region of an image. AHE will over amplify noise in an image. Inorder to limit this over amplification a method called contrast limited adaptive histogram equalization (CLAHE) is introduced. Adaptive histogram equalization (AHE) transforms each pixel with a transformation function derived from a neighbourhood region.

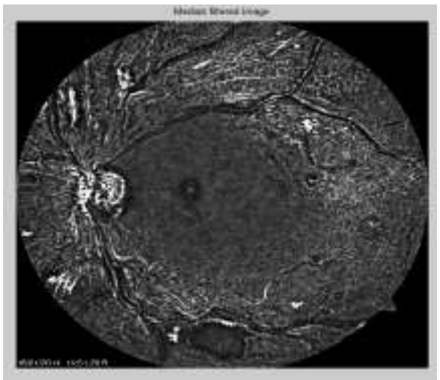

Fig 2 : Preprocessed image

B. Compressed Sensing

CS is the theory of reconstructing large dimensional signals from a small number of measurements by taking advantage of the signal sparsity.

.In the framework of CS, the signals probed are firstly assumed to be sparse or compressible in some basis . Consider a complex-valued signal x which itself may or may not be sparse in the canonical basis but is sparse or approximately sparse in an appropriate basis Ψ. That is, $x = \Psi\theta$.

where θ is sparse or approximately sparse.Due to the fast reconstruction and low complexity of mathematical framework, a family of iterative greedy algorithms has been widely used in compressive sensing recently

At present, the most important Greedy Algorithms include matching pursuit and gradient pursuit. The idea is to select columns of θ in a greedy fashion. At each iteration, the column of θ that correlates most with is selected. Conversely, least square error is minimized in every iteration. Most used greedy algorithms are Matching Pursuit and its derivative Orthogonal Matching Pursuits(OMP) because of their low implementation cost and high speed of recovery.Here I followed a for loop for iteration.3 iterations are take into consideration in which the pixel values are fnally reduced to a range of 140-150.This range of pixel values are poor illuminated or presence of dark lesions. These range of pixel values are taken for further processing.

C. Segmentation

Finding a thresholded value to separate 2 classes is the simplest method of image segmentation**.**Otsu's method, is used for performing automatically clustering-based image thresholding. The algorithm assumes that the image contains two classes of pixels following bi-modal histogram (foreground pixels and background pixels), it then calculates the optimum threshold separating the two classes which makes the inter class variance as maximal and intra class variance as minimal.

The method requires an iterative process. That is, calculations must be repeated using different breaks in the dataset to determine which set of breaks has the smallest in-class variance. The process is started by dividing the ordered data into groups. Initial group divisions can be arbitrary. There are four steps that must be repeated:

1. Calculate the sum of squared deviations between classes (SDBC).
2. Calculate the sum of squared deviations from the array mean (SDAM).
3. Subtract the SDBC from the SDAM (SDAM-SDBC).
4. After evaluating SDBC, move one unit from the class with the largest SDBC toward the class with the lowest SDBC.

This process is repeated with new deviations until the sum of the within class deviations reaches a minimal value.

D. Feature extraction and selection

Feature extraction is a crucial step for the CAD system. It uses different methods and algorithms for feature extraction from the segmented image. Based on the extracted features normality and abnormality of the lung are decided. Use GLCM (Gray level co-occurrence matrix) for the texture feature extraction from RGB fundus image. Feature extraction is a dimensionality reduction. Transforming input data into set of features. In this process, total 20 textural features of all images in the database are extracted using GLCM (Gray level co-occurrence matrix). Then these features are used for tumor classification. GLCM is simply a matrix that gives the sum of the number of times that the pixel with value i occurred in the specified spatial relationship to a pixel with value j in the input image, example of four state space is shown in fig 3.

Contents of the GLCM is used to calculate the texture features to give a measure of the variation in intensity at the pixel of interest. From the co-occurrence matrix obtained, extracted the 20 different statistical features, are Energy, Contrast, variance, Correlation, maximum probability, entropy, homogeneity, cluster shade, cluster prominence, dissimilarity, sum average, sum entropy, sum variance, Difference variance ,Difference entropy, information measure of correlaton1, information measure of correlaton2,Inverse difference moment, autocorrelation.

Feature selection algorithms helps in recognising and classifying systems. If a feature space with large dimension is used, there are chances of decrease in classifier performance in connection to execution time and recognition rate. For determining the best feature subset in same case, automatic feature selection technique can be used for completion of feature space, by varying the number of selected features from 1 to m. By using sequential forward selection algorithm, best features can be easily extracted. After selecting the final feature subset will be sent to classifier for the classification. It is an empty matrix for storing features from SFS.

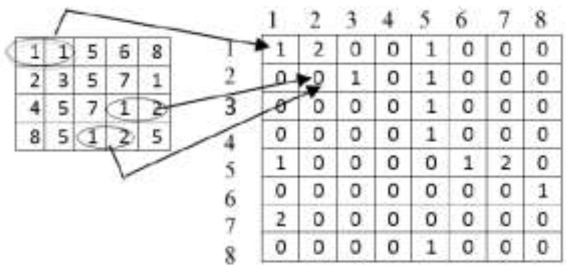

Fig 3: Gray level co-occurrence matrix

Some features selected are as follows:

$$Area = \sum_{i=0,j=0}^{m,n} p(i,j)$$

$$Mean[\mu] = \left[\frac{\sum_{i=0}^{m}\sum_{j=0}^{n} p(i,j)}{m*n}\right]$$

$$Standard\ Deviation\ [\sigma] = \sqrt{\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[P(i,j)-\mu]^2}$$

$$Entropy = -\sum p \log_2 p$$

$$Homogeneity = \sum_{i=0}^{N-1}\sum_{j=0}^{N-1}\frac{P_{ij}}{(1+|i-j|)}$$

By using these extracted features the lesions – Microaneurysms and Hemorrhages are distinguished.

E.Classification

Convolutional Neural Networks (CNN) is variants of MultiLayer Perceptron (MLPs). Convolutional neural networks are designed to process two-dimensional (2-D) image . A CNN architecture used in this project is to identify and classify the severity f the lesion stages for an effective treatment. The network consists of three types of layers namely convolution layer, sub sampling layer and the output layer. The input to the network is a 2D image. The network has input layer which takes the image as the input, output layer from where we get the trained output and the intermediate layers called as the hidden layers.The Convolution network consisits of convolutional and sub-sampling layers in series with . Both the layers together to form an correct output. In this method non-overlapping rectangles are formed by partioning the input image. Maximum value output is obtained for each sub region.

III. EXPERIMENTAL RESULTS

Here, the input images of Diabetic Retinopathy are RGB fundus camera images.RGB images are selected inorder to extract the green pixel values for better extraction of blood vessels. First image selected from the file specified. Then each image is resized to 256*256. Firstly, convert the input image in RGB format into gray scale image after blood vessel extraction, since most of the image processing is done on gray scale images.

Generally, medical images are corrupted with noise and artefacts due to body movements. Median filtring is applied to avoid salt and pepper noise.Then Contrast Limited Adaptive Histogram Equalization (CLAHE) is applied. The contrast limited adaptive histogram equalization algorithm separates the images into contextual regions and applies the histogram equalization to all.

This evens out the allocation of applied gray values and thus makes hidden features of the image more visible by reducing noise and by enhancing the contrast. He compressed sensing technique can only be applied in poor illuminated image or sparse image.this method is applied inorder to find the dark lesions (MA,HEM).iteration method decreases the pixel values such that the poor contrast are is enhanced. Otsu based Thresholding is used to separate the marginal values of 2 classes. In other words, the method minimises the inter class variance and maximses intra class variance.

Then create a GLCM matrix from the images and calculates the statistics specified in properties from the gray-level co-occurrence matrix. After extracting GLCM features of images, best feature is selected using Convolutional Neural network algorithm and lesion classification is done.

Fig 4: RGB fundus image

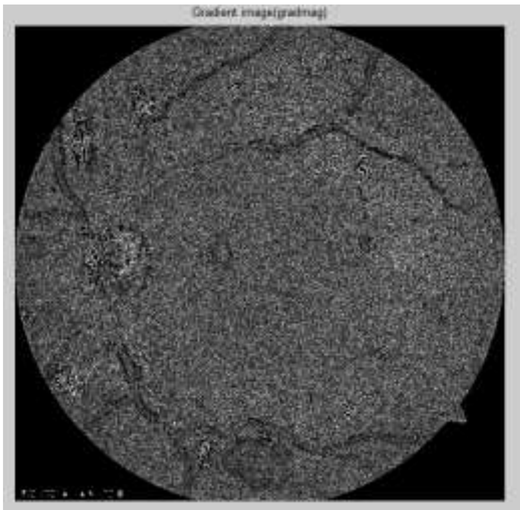

Fig 5: Gradient image

A. Performance Measures

Three widely used performance measures, namely Sensitivity (SE), Specificity (SP) and Accuracy (AC) are used for evaluation purpose. They are expressed as follows:

1. Accuracy (AC) = (TP+TN) / (TP+TN+FP+FN)
   Accuracy in % = 99.97%
2. Sensitivity (SE) = TP / (TP+FN)
   Sensitivity in % = 20%
3. Specificity (SP) = TN / (TN+FP)
   Specificity in % = 96.08%

Where TP= correctly classified lesion regions, FP=non-lesion regions detected as lesion, TN=correctly classified non-lesion regions, FN=lesion regions wrongly classified as non-lesion regions.

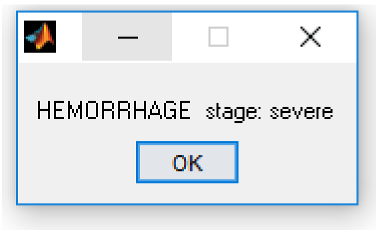

Fig 6: CNN classifier output for severity classification.

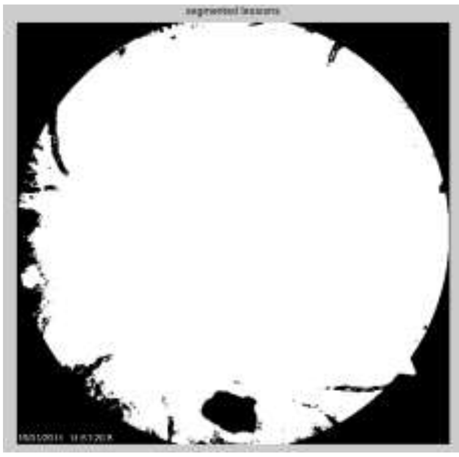

Fig 7: Extracted lesion region

IV. CONCLUSION

An efficient technique to detect MA and HEM is proposed and implemented. The method adopted in this paper for efficient detection of dark lesions in humans eye is reliable and shows accurate results. An efficient automated system for DR is implemented successfully with higher accuracy. Early detection of diabetic retinopathy is very important because it enables timely treatment that can ease the burden of the disease on the patients and their families by maintaining a sufficient quality of vision and preventing severe vision loss and blindness. The proposed techniques work effectively even on a poor contrast image. The method implemented can be used for screening of patients eyeballs for detecting level of DR in a cost effective manner. This technique helps in determining levels of DR in its early stage and thus preventing vision loss.

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