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Detection and Grading of Macular Edema Using Convolutional Neural Network

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Abstract- **The macula is an oval-shaped area near the center of the human retina, and at its center, there is a small pit known as the fovea. The fovea contains large concentrations of cone cells and is responsible for sharp, colored vision. Macular disorders are the group of diseases that damage the macula, resulting in blurred vision or even blindness. Macular Edema (ME), one of the most common types of macular disorder, is caused by fluid accumulation beneath the macula. In this paper, we present an automated system for the detection of ME from fundus images. We introduce a new automated system for the detailed grading of the severity of disease using knowledge of exudates and maculae. A new set of features is used along with a minimum distance classifier for accurate localization of the fovea, which is important for the grading of ME. The proposed system uses different hybrid features and support vector machines for segmentation of exudates. The detailed grading of ME as both clinically significant ME and non-clinically significant ME is done using localized foveae and segmented exudates. In this by using the convolutional neural network algorithm to evaluate the things.**

Index terms- **Convolutional Neural Network, Image analysis, fundus, exudates, and macula**

I.INTRODUCTION

Macular edema is the swelling of either the macula or the Müller cells of the retina. The macula is the most sensitive part of the eye and responsible for sharp vision. In macular edema, the patient experiences edema in the macula due to fluid accumulation underneath the macula. This causes the macula to swell and thicken. The macula has very densely packed cones that are responsible for the minute details in vision. When the macula is swollen, these cones cannot function properly, thus preventing the patient from seeing properly and performing such tasks as driving, reading, or using computers [1].

The main symptom of macular edema is blurred vision. When a patient experiences ME, the central part of the vision becomes blurry while the peripheral vision is unaffected. This can lead to obvious problems for the patient since the center part of the vision is needed for almost all essential tasks like reading, driving, or using computers [2].

II.LITERATURE SURVEY

First for detection of exudates and reported their results in terms of AUC. The team claimed to achieve a reading of 0.96 when the combination of both databases was tested against their approach, and a reading of 0.97 when the databases were tested independently.

Johnny and Thomas [4] checked 30 images for signs of macular edema and determined the severity level of the disease where detected. Of the 30 images checked, their algorithm detected 9 subjects as normal, 8 as moderate, and 13 as severe classification of exudates from digital fundus images. He worked on an algorithm for automatic classification of hard exudates using colored fundus images. They first used adaptive thresholding and then supported vector machines (SVM) for classification. They claim to have achieved high accuracy and specificity, with no false positives.

The algorithm was tested on 189 images from DIARETDB1 and MESSIDOR. On DIARETDB1, the algorithm achieved accuracy of 92.13%, and on MESSIDOR, the algorithm achieved an accuracy of 90% accuracy created a second algorithm for automated detection and grading of diabetic macular edema from digital color fundus images. The algorithm was tested on 89 images of DIARETDB1 and 100 images of MESSIDOR. The algorithm achieved accuracies of 95.45%, 92.11%, and 87.50%

for normal, severe DME, and moderate DME, respectively. On MESSIDOR, accuracies of 92.72%, 90%, and 88.89% were reported for normal, severe DME, and moderate DME, respectively. The researchers claim that the algorithm can be used to determine the severity of the disease.

The algorithm for diabetic macular edema using discrete wavelet transform, discrete cosine transform, and maculopathy index. They claim that the reason for diabetic macular edema is chronic diabetes. Acharaya et al. claimed to achieve an accuracy of 97.01% using publicly available MESSIDOR datasets. The tested 100 fundus images for detection of macular edema using a region-based approach. The images used were from the MESSIDOR database. They achieved an accuracy rate of 90% for different cases. In their paper, they associate the severity of macular edema with the presence of hard exudates in the macular section.

III. PROPOSED METHODOLOGY

The proposed system presents an automated method for the detection and grading of macular edema (ME). The main modules are macula detection, segmentation of exudates, and grading of ME .The proposed system further subgrades the severity levels of CSME and provides a detailed quadrant-wise analysis.

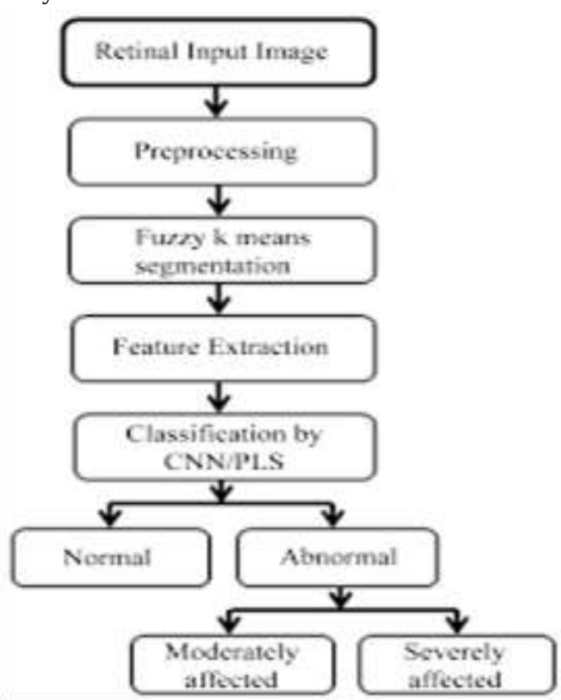

Fig: 1 Flowchart for proposed method

A. PREPROCESSING

The first stage of the proposed algorithm is pre-processing in which multiple steps are carried out to improve the quality of input image. Preprocessing stage separates the foreground (fundus region) from the background so that all upcoming steps only consider the fundus region. This is carried out using adaptive thresholding followed by morphological operations .Second step in preprocessing stage is to improve contrast between different components i.e. blood vessels, macula, optic disc etc. and fundus background. We are using histogram equalization, for contrast enhancement.

Fig: 2 Input retinal image

B. SEGMENTATION

1. MACULA DETECTION

In this paper, a new supervised training-based method for macula detection is presented. Figure 3 shows the system level diagram of proposed macula detection algorithm

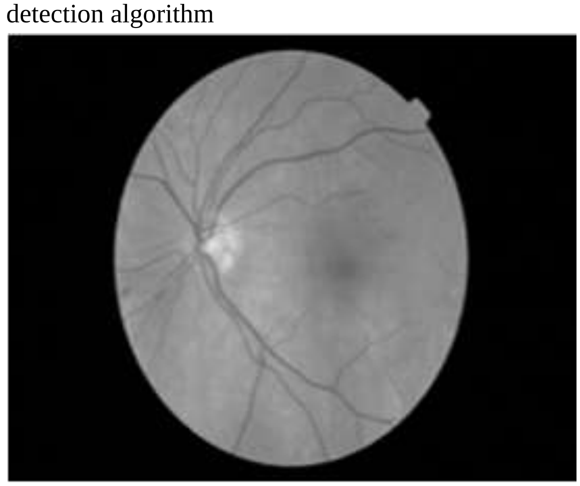

Fig: 3 Grey Scale Image

Fig: 4 Adaptive Thresholding

The algorithm takes original fundus images and their corresponding, manually extracted, macular region for generation of a supervised training feature vector. In the testing phase, the same features for all possible candidate macular regions are extracted and then they are passed to the minimum distance classifier. The classier selects the region with the closest distance from training feature vector.

2. GENERATION OF FEATURE SET FOR TRAINING

The main step of training the system is generation of the feature set. In this step, we crop the macular region manually for all training images. The next step is to represent macula regions with the best features. These features are selected so as to represent actual behavior of macula in fundus images.

The following four features are extracted:

- Area of Macula (f1): It represents the total number of pixels a macular region contains.
- Distance from the Optic Disc (f2): This feature computes the distance between optic disc centre and macula region.
- Mean Intensity Macula region is normally blackish in color and in order to differentiate macula region from other dark regions in the fundus image like hemorrhages and blood vessels, mean intensity is taken as a feature.
- Angle between the Macula and the Optic Disc (f4): Forth feature is angle between optic disc and macula.

Fig: 5 Adjusted Image

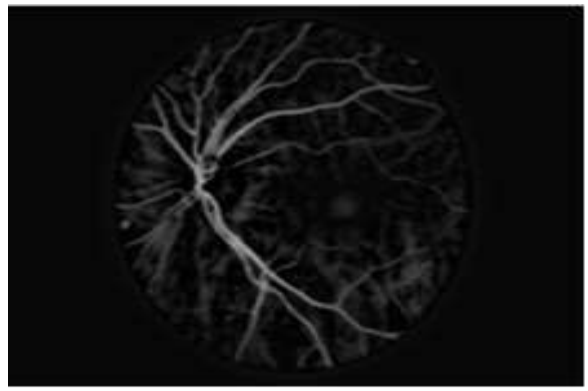

Fig: 6 Complemented Adjusted Image

All of these features are used to classify the regions in the testing stage. These features are all normalized, and the average of the features is used to determine the normalized mean feature for the macula, which is used later with the minimum distance classifier for testing.

3. MACULA DETECTION FOR TEST IMAGE

Following generation of the training feature vector, the second phase of the proposed system is analyzing fundus images for automated detection of macula. This phase extracts all possible macular candidate regions in addition to the features mentioned above to detect actual macula location. This stage applies adaptive thresholding technique to extract all possible candidate regions which may contain macula. The macula region has a similar intensity to that of blood vessels and some lesions such as hemorrhages. This can make macula detection a bit tricky. In the proposed system, we remove vessel pixels from all candidate macula regions to eliminate false candidate regions. Blood vessels are extracted using Gabor wavelets and multilayer thresholding techniques. These extracted blood vessels are removed from candidate regions to eliminate false positives which occur due to similarity between vessels and macula regionsm here.

Fig: 7 Feature Extraction of Macular Region

IV. FEATURE EXTRACTION OF MACULAR REGION

The extraction stage mentioned above calculates the area of macula, distance from the optic disc, mean intensity, and angle from the optic disc. All of these features are extracted for each candidate region, sample regions taken from a single fundus image whose features have been extracted. The first entry in the table is for the true macula region, and it is evident that the extracted features clearly discriminate between true and false macula regions.

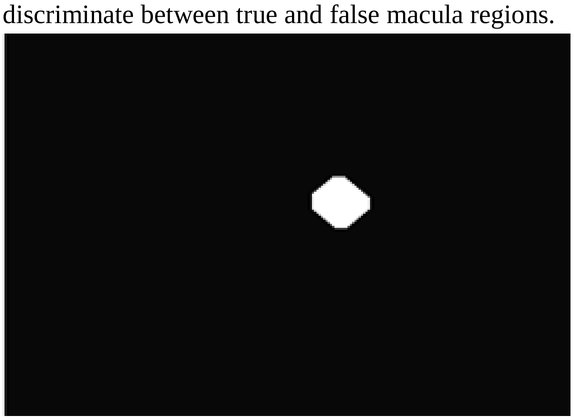

Fig: 8 Spotted Macular Region

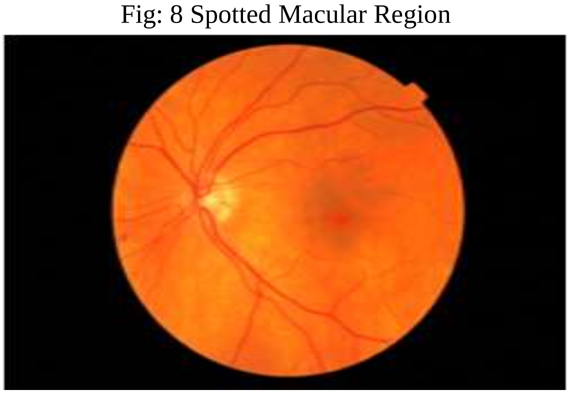

Fig: 9.Highlighted Macular Region

V. CONVOLUTIONAL NEURAL NETWORKS

The Convolutional Neural Networks (CNN) is one of the most famous deep learning algorithms and the most commonly used in image classification applications. In general, the CNN architecture contains three types of layers, which are convolutional layers, pooling layers and fully connected layers.

The CNN algorithm receives an input image that passes through the layers to identify features and recognize the image, and then it produces the classification result. The architecture of the CNN contains alternating convolutional layers and pooling layers, followed by a set of fully connected layers.

The output of each layer in the CNN is the input of the following layer. The input of the CNN is a 3D image (width × height × depth), the width and the height are the dimensions of the images. The depth is the number of input channels and it is three color channels Red, Green, and Blue (RGB).

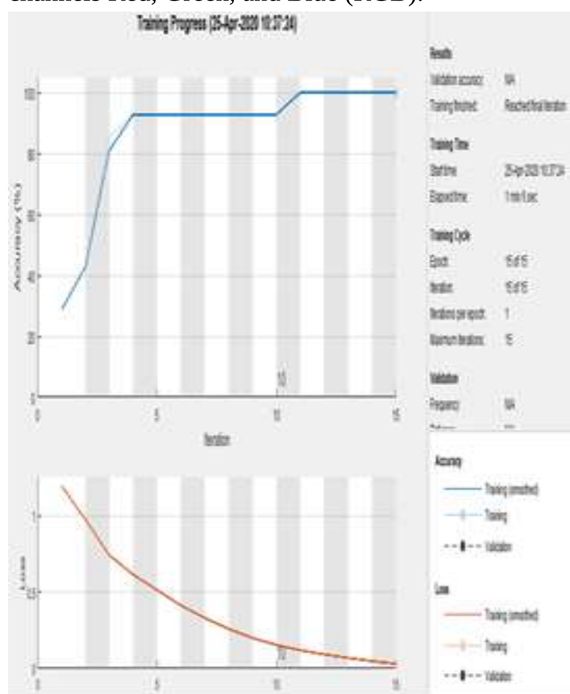

Fig: 10 Training process

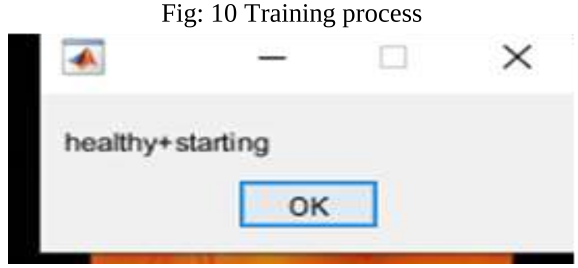

Fig: 11.Grading of Macular Edema

The convolutional layers extract features from images. Each convolutional matrix has matrix weights that are called filters or kernels which slide over the input image to detect particular information from the image. The filters of the first layers of the CNN detect colors and simple patterns. Then in the next layers, they gradually detect more complex patterns. To find features, each filter applies a convolution operation to output a feature map.

VI.CONCLUSION

We have presented an automated method for the detection and grading of macular edema. Our approach detects both the location of exudates and the location of the macula. Following this, we are passing the image through convolutional, pooling, fully connected layers and the exudates, the severity of the disease is classified. Therefore, by examining the exudates from the macula, we are able to mark the images as normal, mild, moderate, or severe. Our approach yielded excellent results and was tested on four separate datasets, three of which are publicly available.

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