Retinal Microaneurysm Detection by CNN

Deepa R 1, 2 and N K Narayanan3

1Department of Information Technology, Kannur University, Kannur, Kerala, India
2Department of Computer Applications, College of Engineering, Vadakara, Kozhikode-673104, Kerala, India
3Indian Institute of Information Technology, Kottayam, Valavoor (P.O), Kottayam-686635, Kerala, India.

E-mail: deepashaaju@gmail.com

Abstract. Diabetic Retinopathy (DR) is a fast-growing retinal disease happens as a result of exponential growth in sugar level in blood which diminishes eyesight. The severity level identification of this eye disorder is performed by ophthalmologists due to scarcity of good software for finding DR. The initial stage of diabetic retinopathy is identified by the presence of microaneurysm. This paper conducts the initial phase detection of the disease by using Convolutional Neural Network (CNN). For conducting experiment DIARETDB1 dataset used. The images from the database are resized as a preprocessing step then automatic feature extraction done by the simple CNN used. By performing training, the CNN network classifies images with and without disease. The Sensitivity, Specificity and Accuracy obtained by the technique explained is 97.62%, 100% and 97.75%.

1. Introduction

Diabetic Retinopathy (DR) affects retina, and it occurs due to increase in glucose level [1]. The difficulty of earlier identification of this disease is because it will not show symptoms at very earlier stage. When disease progresses vision blurring and loss of vision occurs. The symptoms of starting of DR are microaneurysm, haemorrhage and exudates and this stage is called as Non-Proliferative Diabetic Retinopathy. Disease progresses increased growth of vessels occurs and called as Proliferative Diabetic Retinopathy [2]. The initial visible sign of DR is microaneurysm (MA). MA’s are very small red colored dots of size 10 to 60 micrometer in diameter. Fundus image not having microaneurysm is indicated in figure 1(a) and having microaneurysm is indicated in the figure 1(b). The objective of this work is to automatically detecting microaneurysm which is the initial clinical symptom of diabetic retinopathy disease. In this work the disease is detected by using CNN which helps automatically extracting relevant features. By using CNN network the images in the database used is trained. In the testing stage the CNN network classifies images with disease and images without MA.

![Figure 1(a). Fundus Image not having MA](image1)

![Figure 1(b). Fundus Image having MA](image2)
2. Related Work

The techniques for MA detection have commonly three steps. In step 1 candidates like MA are found out. In step 2 features are extracted for every candidate and step 3 is classifying MA and without MA. Dashbozorg et. al. [3] found out a microaneurysm identification method which performs preprocessing, gradient weighting technique and iterative thresholding technique for candidate extraction. Shape, intensity features and a collection of features that depends on local convergence index filters are taken. In order to separate MA from non-MA hybrid boosting classifier is used. On the ROC dataset the method gave average sensitivity score as 0.471. Habib et. al. [4] developed a MA identification method using ensemble classifier. Detection of candidates done by Gaussian matched filter. This approach used to reduce false positive rate. All relevant features extracted. The classifier used is tree ensemble classifier. Datasets used by this method are DIARETDB1v2.1 and MESSIDOR. This technique gives Receiver Operating Curve (ROC) value as 0.4150.

Purwita et. al. [5] developed a MA detection method where mathematical morphological method is used the database used is DIARETDB1.

Antal et. al. [6] proposed an ensemble technique to find out microaneurysm detection and for grading. The database used is MESSIDOR in this technique. The AUC obtained in classification is 90%.

Fleming et.al. [7] developed a MA detection technique which explains how contrast normalizing of image helps distinguishing MA and other dots. Watershed transformation approach used in region without vessels and by using vessel detection approach dots in vessels are identified. Specificity 83.1% and Sensitivity 85.4% obtained.

Inoue, Tsuyoshi, et al. [8] suggested a MA detection approach using Eigen value analysis by Hessian matrix in green channel of fundus image. By thresholding false positives eliminated. ANN classifies MA and non-MA. Feature reduction done by PCA. On ROC database true positive rate 73% obtained. Zhang, Bob, et al. [9] developed an approach for MA detection where multiscale correlation filtering and dynamic thresholding used. Evaluation performed by ROC and DIARET DB 1 database.

Ekapure et. al. [10] proposed a method which uses Gaussian filter for extracting blood vessels to detect red lesion SVM classifier differentiate image with lesion and without lesion. DR detected in mild, moderate and severe cases. The sensitivity 88% and specificity 92% obtained.

Manohar et. al. [11] proposed an MA detection technique which use morphological method for detecting microaneurysm. False elimination is performed. The database used is DIARETDB1. Sensitivity 80.41% and specificity 92.79% obtained.

Murugan et. al. [12] proposed MA detection method in which as pre-processing step adaptive histogram equalization is done. Then MA segmentation done which removes distractors. Datasets used are DRIVE, STARE and DIARET DB0.

Aleena et. al. [13] detected microaneurysm in which Top hat and bottom hat transform approach are used for the enhancement of the image for the MA detection. SVM classifies dark lesion to microaneurysm and haemorrhages.

Walter et. al. [14] proposed a MA detection technique in which after pre-processing candidates are extracted by diameter closing and thresholding scheme. Based on kernel density estimation with variable bandwidth classification is performed.

Wu et. al. [15] Proposed a method where after performing pre-processing and extracting candidates, 27 features are extracted to classify MA and non-MA. The databases used are ROC and e-optha. All the systems that are existing performs well but they also have many disadvantages. Microaneurysm detection system is facing difficulty due to camera properties while dealing with fundus images. The MA is having variable size and shape so these factors also make difficulty in detection of MA [3].

The proposed method is a convolutional neural network based MA detection. This paper solves several issues discussed above. The proposed method initially resized the image from 1500 X 1152 to 250 X 250 otherwise very high capacity machines can only process the image. The relevant features are extracted by the network due to appropriate training and finally CNN classifies diseased and normal.

3. Proposed Work

The disease detection from fundus image is done by the steps shown below. The figure 2 shows the steps for microaneurysm detection using CNN.

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Figure 2. The Steps for Detection of Microaneurysm.

3.1 Convolutional Neural Network
In the case of CNN the original image of size 1500 X 1152 is resized into 250 x 250 size before processing. An advantage of CNN is automatic detection of features. Basic CNN architecture used in the proposed method is shown below as figure 3.

Figure 3. Basic CNN Architecture used in the Proposed Method.

4. Feature Extraction
In the case of CNN network by the help of several hidden layers it is possible to automatically extract features.

5. Classification
The diseased and normal images are classified using convolutional neural network. CNN Classifier have in addition to input and output, multiple hidden layers. ReLU activation function is commonly used and it is accompanied by pooling layers then fully connected and normalization layers. The fully connected layers will connect neurons in one layer to another layer.
6. Experimental Details
To conduct experiment in this case the DIARETDB1 database used. In the database 89 fundus images are present. For conducting experiment 56 images allotted for performing training. Technique used for experiment is CNN training and testing. Figure 4 shows CNN training.

7. Results and Discussions
The values obtained after evaluation is shown in Table 1.

|                      |          |
|----------------------|----------|
| Accuracy             | 97.75%   |
| Sensitivity          | 97.62    |
| Specificity          | 100      |
| Error Rate           | 2.25     |
| Precision            | 100      |
| False Positive Rate  | 0        |

The table 1 describes the results obtained. CNN classifies 97.62% diseased images as diseased. CNN correctly classified normal images as normal. Figure 5(a) gives evaluation measures by CNN. Figure 5(b) shows Pie diagram of CNN.
Table 2. Obtained and Predicted class for Microaneurysm Detection using CNN

| Image | Obtained Class | Predicted Class |
|-------|---------------|-----------------|
| 39    | No MA         | No MA           |
| 46    | MA            | MA              |
| 50    | MA            | MA              |
| 62    | MA            | MA              |
Table II shows the obtained and predicted class for microaneurysm detection using CNN and in table III the proposed technique is compared with other available techniques for detecting microaneurysm and from the table it is possible to conclude that proposed method is better than other methods.

| Method             | Sensitivity% | Specificity% |
|--------------------|--------------|--------------|
| Fleming et.al. [7] | 85.4         | 83.1         |
| Ekatpure et. al. [10] | 88         | 92          |
| Manohar et. al. [11] | 80.41       | 92.79        |
| Proposed Method    | 97.62        | 100          |

8. Conclusion
Diabetic retinopathy if untreated cause vision loss and its earlier diagnosis helps earlier treatment. In the starting stage of diabetic retinopathy microaneurysms are seen. Initial stage detection of diabetic retinopathy is very difficult and there are no proper software available for the detection at earlier stage. This paper gives initial stage detection of diabetic retinopathy using CNN classifier. Based on experiment conducted and result obtained and comparing with the state of art techniques the method gives better result. As a future enhancement an ensemble method may give better result.

9. References
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