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# A Review on Automated Detection and Classification of Diabetic Retinopathy

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## Abstract

*Diabetes, which occurs due to constant increase of glucose in the blood, is a main health threat. Overtime diabetes affects organs, including retina. Diabetic retinopathy is a disease affecting retina due to leakage of fluid from blood vessels in the retina. Eye specialists detects and classifies diabetic retinopathy as NPDR and PDR based on the presence of features such as microaneurysms, hemorrhages, hard Exudates, soft Exudates, neovascularization, leakages etc. This review shows the different approaches used for identifying the features and classification of the disease as mild or severe.*

***Keywords***
*Microaneurysms, Hemorrhage,*
*Exudates, neovascularization, leakages.*

## 1. Introduction

Diabetes, which occurs due to chronic increase of glucose in blood . It is seen all over the world and is more common in developed countries. The increase in rates has been seen in low and middle income countries, where more than 80% of diabetic deaths occur. The rate increases in developing countries also due to life style changes i.e. less physically demanding work and global nutrition transition, increased intake of foods that are less nutrient and high energy-dense.

Diabetic retinopathy (DR) is one among the severe complications of diabetes mellitus which damages the retina and results vision loss if not treated on time. Major problem in this disease is that patient affected by diabetes mellitus requires continuous screening to detect the disease earlier. Eye diseases such as DR are identified by structural variations in retina. Early detection of diabetic retinopathy is needed for successful treatment

### 1.1 Diabetes

Diabetes mellitus(DM) or diabetes is a collection of metabolic disorders due to increased blood sugar levels over a long period. Diabetes occurs either due to pancreas not secreting enough insulin or the body cells not responding to produce insulin. Mainly three types of diabetes mellitus.Type1 DM is due to the failure of pancreas to produce enough insulin.Type2 DM starts with resistance to insulin in which cells fail to respond to insulin properly. Gestational diabetes occurs in pregnant women without previous history of diabetes develops high blood sugar levels.

### 1.2 Causes

Diabetes can be attributed to an aging population and due to obesity , life habits etc. Genetic reasons also cause type 1 and type 2. Type 1 also occurs due to some infections.

### 1.3 Effects

Diabetes if untreated results several complications. Some complications are cardiovascular disease, stroke, kidney failure, foot ulcer, eye damage etc.

## 2. Diabetic retinopathy

People with diabetes can have an eye disease called diabetic retinopathy. This is due to high blood sugar levels which cause damage to blood vessels in retina. These blood vessels may swell, leak, or stop blood from passing through. In some cases new abnormal vessels grow on retina. All these changes affects vision. Ophthalmologists recognize diabetic retinopathy based on features, such as microaneurysms, haemorrhages, exudates ,blood vessel area, leakages and texture[1].

## 3. Stages of diabetic retinopathy

There are two main stages of diabetic eye disease.

### 3.1 NPDR (non-proliferative diabetic retinopathy)

This is the early stage. Tiny blood vessels may leak which makes the retina swell. Swelling of macula is macular edema which is a reason for people with diabetes have vision loss. With NPDR blood vessels in the retina can close off called macular ischemia and due to that blood cannot reach the macula. Symptom of NPDR is blurred vision. Eye specialists can recognise NPDR based on the presence of microaneurysms, haemorrhages, exudates etc.

### 3.2 PDR(proliferative diabetic retinopathy)

PDR is the advanced stage of the disease . It is characterised by the formation of new blood vessels. This is called neovascularisation. If disease progresses this new blood vessels may leak and finally detachment from retina results. PDR affects central and peripheral vision.

## 4. Detection methods

Early detection of the disease is important. If disease progresses it is difficult to treat. Treatment methods are mainly using laser technology.

**Fundus images**

Several imaging modalities are used to detect diseases now. Fundus images help doctors for easy diagnosis of diabetic retinopathy. To take fundus image first it is required to dilate the pupil by mydriatic eye drops. The patient is asked to stare at a fixation device in order to steady the eyes. When taking the pictures , the patient can see a series of bright flashes. The entire process takes about five to ten minutes.

## 5. Feature extraction methods and analysis

Image processing can do a major role in disease diagnosis. The following sections describe automated detection of DR by different approaches used for finding out features such as microaneurysms, haemorrhages, exudates, neovascularisation, leakage etc.

### 5.1 Microanuerysms

Microanuerysms are the first clinical symptoms of DR.They are capillary swellings. Size of MA range from 10 to 125 micro metres. It appears as tiny reddish dots[2].

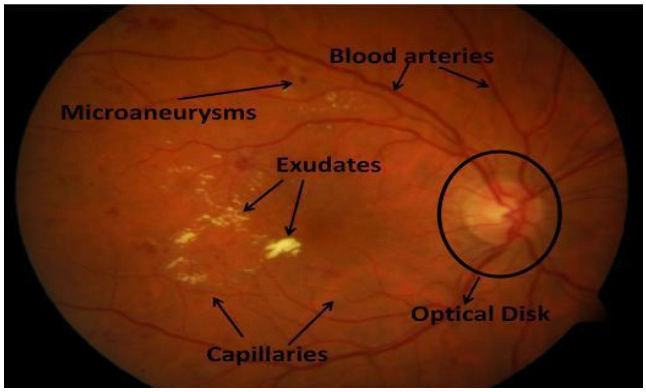


Fig 1: microanuerysms

Habib *et al* [3] proposed a method for detection of microanuerysms in retinal images using an ensemble classifier, initially detects a set of candidates using a Gaussian matched filter and then classifies this set to reduce the number of false positives. A tree ensemble classifier is used with a set of 70 features. The algorithm is evaluated by using public datasets MESSIDOR and DIARETDB1v2.1 . The method achieves an ROC score of 0.415.

Sumathy *et al.*, [1] have explained a method for the automated detection of microanuerysms and grading of diabetic retinopathy there are two parts. One is preprocessing in which firstly the RGB image is resized to the standard size. Then, green channel component is extracted using suitable method. MA appear in the highest contrast in green channel. Noise removal is done by median filter and then contrast limited histogram equalized image for the fundus image is obtained.This adaptive method shows the individual MA identification in an efficient manner. Shade correction is used to eliminate large scale image variations . Second part is candidate extraction this is done to improve the true detection of MA and to avoid the false positives for this MA like structures such as blood vessels and other healthy features such as optic disk and macula should be removed. The segmented blood vessels are obtained by set of morphological procedures like top hat transform followed by Gaussian filter, which filter out small structures. The resulting image after blood vessel removal consists of MAs and little noise. Noise is to be removed based on features like area, perimeter, Roundness metric, Energy, correlation etc. Finally, based on the roundness metric i.e. circulatory feature, MAs are extracted. This method has very high specificity, which shows that algorithm does not recognize non-microanuerysms pixel as microanuerysms.

Wang et al[4] proposed a method for MA detection which performed on the green channel of retinal images as MAs, haemorrhages, and vessels normally present the highest contrast against the surrounding background colour channel. MA detection is divided into pre-processing, candidate extraction through multilayered dark object filtering, candidate cross section profile analysis based on SSA, feature extraction, and classification. The average sensitivity and specificity achieved are 96.3% and 88.4%, respectively.

Antal et al [5] proposed an ensemble-based (ensemble-A group of items viewed as a whole rather than individually) framework to improve microaneurysm detection and diabetic retinopathy grading. Reliable microaneurysm detection in digital fundus images is still an open issue in medical image processing. This method is tested by using

the publically available Messidor database where AUC approximately 90% is achieved.

## 5.2 Hemorrhages

DR advances retinal haemorrhages arises. If their number increases vessels of retina damages and leakage of fluid, lipid and protein results.

Seoud et al[6] proposed a method for the automatic detection of both microaneurysms and hemorrhages in colour fundus images the method achieved an AUC of 89%.

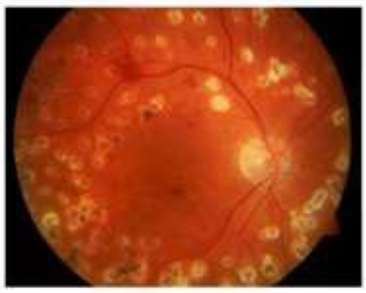

Fig 2. Exudates

Larsen et al. used image processing techniques for detecting haemorrhages and microaneurysms[7].The algorithm gives specificity of 71.4% and sensitivity 96.7% Detection of red lesions in colour fundus photographs is a step in development of automated screening systems for diabetic retinopathy[8]. The method obtain a sensitivity of 100% at specificity 87% .

## 5.3 Exudates

If disease progresses exudates appear as bright patches in retina. They can be of various sizes and shapes and can be of two types hard and soft exudates.

Choudhury et al [9] deals with feature extraction of retina using Fuzzy C Means and morphological methods and classification of whether the patient is suffering from diabetic retinopathy or not using Support Vector Machines (SVM). An automated detection of diabetic retinopathy is thus possible through this classification. The system comprises of an approach of detecting two features: the blood vessel density and exudates which leads into the detection of the stages of diabetic retinopathy. The fundus images are first passed through morphological segmentation methods to extract the retinal vessels and then the exudates are extracted by Fuzzy C means based segmentation and morphological techniques. The retinal vessel density and the exudates density being the two features are fed to the SVM to optimally classify the images into their respective classes, thereby obtaining an overall accuracy of 97.6%.

## 5.4 Neovascularisation

Proliferative diabetic retinopathy(PDR) is characterised by the growth of new abnormal blood vessels and may results in detachment from retina.

In Kar et.al.Curvelet transform is used to intensify the fine details of the vessels followed by maximization of mutual information on the maximum matched filter response for optimal thresholding to partition the vessels into thick and thin categories. Vessel density and turtuosity are calculated from thin vessel class followed by MI maximization and post-processing for neovascularisation detection. Accuracy 97.49% achieved in abnormal vessel detection[10].

## 5.5 Leakage

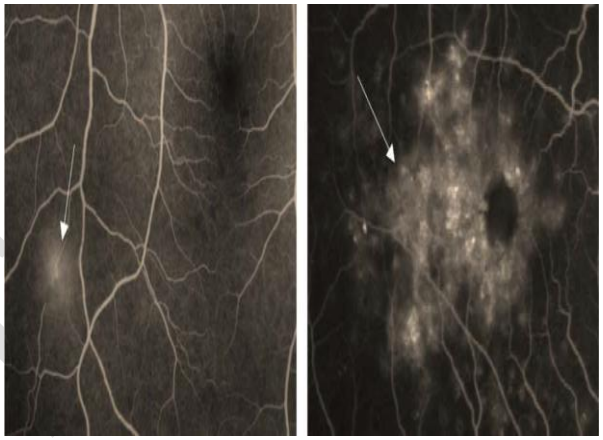

Fig 3. Leakage from Retinal vessels

If disease further progresses leakage from retinal vessels occurs: In [11] Zhao et al. proposed a saliency based method (salient regions are those regions of a medical image that contain meaningful information for diagnostic purposes) for detection of diabetic retinopathy at the leakage stage. Imaging modality used is fundus fluorescein angiography. They used unsupervised technique to detect and quantify leakage regions. Super pixel algorithm called Simple Linear Iterative Clustering is employed in this work to generate a desired number n of super pixels. Evaluation metrics used are sensitivity (Se), specificity (Sp), accuracy (Acc), area under the receiver operating characteristic curve (AUC) and Dice coefficient (DC).They have conducted the experiment on DR dataset and the performances obtained are approximately Se -78%, Sp- 94%, Acc- 89%, AUC- 86% and DC- 81%.

Rabbani et al.[12] proposed a method to detect leakage in FA images of subjects with diabetic macular edema. They employed an active contour segmentation model to detect the boundaries of leaking areas and have a relatively low sensitivity of 69% on 24 images of DR dataset.

Comparison of different classification methods

| Authors | No of classes | Feature | Accuracy | Sensitivity | Specificity |
|---|---|---|---|---|---|
| Sumathy *et al.*, 2013 [1] | 2 | microanuerysm | Not reported | Not reported | Not reported |
| Habib *et al* 2017 [3] | 2 | microanuerysm | ROC: 0.415. | Not reported | Not reported |
| Wang et al 2017 [4] | 2 | microanuerysm | Not reported | 96.3% | 88.4% |
| Antal et al 2012 [5] | 2 | microanuerysm | AUC: 90% | Not reported | Not reported |
| Seoud et al 2016 [6] | 3 | Microanuerysm, haemorrhage | AUC:89% | Not reported | Not reported |
| Larsen et al 2003 [7] | 3 | Microanuerysm, haemorrhage | Not reported | 96.7% | 71.4% |
| Niemeijer et al 2005 [8] | 2 | haemorrhage | Not reported | 100% | 87% |
| Choudhury, S., et al.2016 [9] | 3 | Exudates,neovascularization | 97.6%. | Not reported | Not reported |
| Kar et.al.2017[10] | 2 | neovascularization | 97.49% | Not reported | Not reported |
| Zhao et al.2017 [11] | 2 | leakege | 89% | 78% | 94% |
| Rabbani et al.[12] | 2 | leakege | Not reported | 69% | Not reported |

## 6. Discussion

Diabetes leads the formation of microanuerysms , haemorrhages, exudates etc which results in vision loss.In order to prevent it earlier detection of DR is required. It is very difficult to find out microanuerysms as it resembles some other features in the retina. Detection of haemorrhages, exudates are also challenging and due to that efficient algorithms are needed .

Authors have classified into two classes and more than it.By some techniques discussed above classification efficiency is more. If an algorithm which find out all features for DR and it also classifies NPDR and PDR too it will be more robust.The accurate detection of all these features is challenging but still by image processing and dataminig technuiques it may be possible.

## 7. Conclusions

Increased diabetes causes DR, where the retina damage occurs due to leakage of fluid from blood vessels. The stages of DR is based on the presence of features like microanuerysms, neovascularisation etc. In this paper discussion regarding different feature extraction techniques are presented. Early detection of disease prevent vision loss so regular screening of patient with diabetes is needed.

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