A Systematic Review for Diagnosis of Diabetic Retinopathy using Fundus Images

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Abstract: Diabetes is a very common disease worldwide. Diabetes is a metabolic disorder in which the body cannot appropriately store and consume the glucose in food that leads to the failure of various organs including retina of the eyes. Diabetic Retinopathy is a medical condition where the retina is damaged because fluid leaks from blood vessels into the retina which affects the eyes and results in blindness. Hence, Automated Diabetic Retinopathy detection systems have gained huge attraction nowadays. These systems utilize machine learning and image processing approach to sense various abnormalities related to diabetic retinopathy. Various methods of DR detection and classification, along with implementation technology, tools and fundus image datasets used for the research are discussed in this paper.

Keywords: Diabetic retinopathy, Fundus Imaging, Abnormal features.

I. INTRODUCTION

Diabetic Retinopathy (DR) is an eye disease due to diabetes which causes visual loss. So it is reasonable to provide treatment for DR at first stages of disease.

Figure: - Fundus images (a) Normal retina, (b) Retina with DR

Diabetic retinopathy (DR) can cause due to the improper blood sugar influence in the body namely diabetes. Diabetes causes a major problem in the eyes and it is the important factor to cause blindness all over the world. It is caused when diabetes causes damage to blood arteries and vessels of the retina. DR is the frequent micro vascular complications of diabetes and most causes of blindness and vision loss in the world and actually there are no early symptom of DR. DR affects the retinal vascular structure and leads as progressive retinal damage.

There are two types of DR:
1] Non-proliferative Diabetic Retinopathy (NPDR) [15] [17]:
This is the milder type of diabetic retinopathy and is generally doesn’t show any symptoms.

2] Proliferative Diabetic Retinopathy (PDR) [15] [17]:
PDR is the most difficult level of diabetic retinopathy and refers to the formation of new, abnormal blood vessels in the retina.

Figure: - kinds of Diabetic Retinopathy (a) Proliferative DR. (b) Non-proliferative DR.
II. DIABETIC RETINOPATHY PREDICTION:-

DR prediction is the process of identifying whether the patient is affected by DR, given the set of the patient’s input fundus images. The four stages of diabetic retinopathy are classified as mild, moderate, and severe non proliferative and proliferative.

Table: - four stages of diabetic retinopathy

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mild non-proliferative retinopathy</td>
<td>In the first stage, mild non proliferative, there will be balloon-like swelling in small areas of the blood vessels in the retina.</td>
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<tr>
<td>2. Moderate non-proliferative retinopathy</td>
<td>In the second stage, known as moderate non proliferative retinopathy, some of the blood vessels in the retina will become blocked.</td>
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<tr>
<td>3. Severe non-proliferative retinopathy</td>
<td>The third stage, severe non proliferative retinopathy brings with it more blocked blood vessels, which leads to areas of the retina no longer receiving adequate blood flow. Without proper blood flow, the retina can't grow new blood vessels to replace the damaged ones.</td>
</tr>
<tr>
<td>4. Proliferative diabetic retinopathy (PDR)</td>
<td>This is the advanced stage of the disease. Additional new blood vessels will begin to grow in the retina, but they will be fragile and abnormal. Because of this, they can leak blood which will lead to vision loss and possibly blindness</td>
</tr>
</tbody>
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III. LITERATURE SURVEY

Title: - “Retinal fundus diseases diagnosis using image mining”, (2015)

The main purpose of the paper is to detect the glaucoma and diabetic retinopathy which causes vision loss. The system takes training images to classify them as normal, glaucoma or DR. Discrete Cosine Transform is used for feature extraction. For disease classification KNN algorithm is used.

<table>
<thead>
<tr>
<th>Advantages</th>
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</thead>
<tbody>
<tr>
<td>1. Use to determine images as normal, glaucoma and diabetic retinopathy</td>
</tr>
<tr>
<td>2. Gives better accuracy and efficiency as compared to other methods</td>
</tr>
</tbody>
</table>

Title: - “Feature extraction from the fundus images for the diagnosis of Diabetic Retinopathy”, (2016)

To assist early stage of a Diabetic Retinopathy detection of lesions in a fundus image is necessary. This paper uses MAHM algorithm. Manoj Kumar S B, Manjunath R, Dr. H S Sheshadri [13] proposes new parameter for optic disk detection which detects the major vessels and later use the intersection of these to find the approximate region for optic disk. In the further step this region is localized by applying color properties. This system uses color fundus images as input.

<table>
<thead>
<tr>
<th>Advantages</th>
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<tbody>
<tr>
<td>1. Provides an efficient framework for Diabetic Retinopathy.</td>
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<tr>
<td>2. Various features such as hemorrhages, micro aneurysms, hard exudates and soft exudates can be detected.</td>
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<table>
<thead>
<tr>
<th>Disadvantages</th>
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<tbody>
<tr>
<td>Can only detect Diabetic Retinopathy</td>
</tr>
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</table>
“Features Extracted from Fundus Images Using SVM (Support Vector Machine)"

“R. Adalarasan”, et al [3] describes the extraction of normal and isolated characteristics or marks in color retinal images. The adaptive filters are tuned to match the lump (part) of vessel to be extracted in green channel images. The soft exudates color and intensity were close to fundus color. The lesions breed of interest was micro aneurysms, haemorrhages, hard exudates, soft exudates and neovascularization. The precision of exudates perception appears to be good since exudate pixels were accurately classified as exudates and further pixels as non-exudates by Biogeography Based Optimization Algorithm.

**Advantages**

- Color based approach for identifying hemorrhages, hard exudates, and soft exudates.

**Figure: - Normal and abnormal features of DR image. [2]**

**Title: - “Automatic Detection of Blood Vessel in Retinal Images”, (2016)**

Correct detection of blood vessels is essential for identification of many retinal diseases like DR, hypertension. In paper [14], a method for automatic detection of blood vessels was proposed which uses Hessian matrix for vessel detection. The vascular structure is identified by using eigenvalues of Hessian matrix after convolving image with Gaussian kernel.

**Advantages**

- Applicable to both healthy as well as abnormal retinal images.

**Disadvantages**

- Vessel segmentation has been done without the elimination of Optic disc.

**Figure: - Color based approach. [3]**

**Title: - “A computer-aided healthcare system for cataract classification and grading based on fundus image analysis”, (2015)**

Liye Guo, Ji-Jiang Yang, Lihui Peng, Jianqiang Li, Qingfeng Liang [8] proposed a method which analyzes retinal fundus images and based on features extracted detects cataract condition, if present. Based on severity, cataract is graded as mild, moderate or severe. The feature extraction is performed using 2 methods: Wavelet transform and sketch based methods together with direct cosine transform.

**Advantages**

1. Along with cataract and non-cataract classification, method gives grading for condition according to severity.
2. Features which cannot be identified in space domain are easy to recognize in frequency domain.

**Disadvantages**

- Only able to identify cataract disease.

**“Computer Aided Diagnosis System for Diabetic Retinopathy”**

“Romany F. Mansour” [8] survey revealed that evolutionary computing methods can play vital role for optimizing DR-CAD functional components, such as pre-processing by enhancing filters coefficient, segmentation by enriching clustering, feature extraction, feature selection, and dimensional reduction, as well as classification. Robust and efficient computer aided diagnosis (CAD) system to enable earlier DR detection and optimal diagnosis decision. The prime objective of these
CAD solutions is to identify DR features earlier and identify severity of the DR. To enhance these approaches a number of evolutionary computing algorithms such as GA, PSO, ACO, BFO, DE etc have been applied which primarily functions towards enhancing functional extraction parameters and feature selection. PSO being a stochastic heuristics optimization method takes extracted features from the RR correlation analysis and employs swarm intelligence approach to identify optimal solution by estimating global minima. PSO avoid crossover and mutation processes and thus avoid significant computational overhead.

| Advantages | 1. Number of technologies developed for diabetic retinopathy (DR) has been studied and respective strength as well as weaknesses has been assessed.  
| PSO algorithm that significantly reduced time complexity. |

“K-means clustering for DR Detection”

The techniques like K-means [5] clustering and color space features are used to segment exudates, a lesion of diabetic retinopathy. Pixel color list data structure is used to enable faster clustering. In first step, unnecessary fundus mask is removed by applying Thresholding, after it color transformation constructed two feature spaces, i.e., f1 and f2. The results of clustering confirm that exudates are bright lesions, and there color is yellow.

| Advantages | Method is evaluated using DIARETDB1 dataset and sensitivity of 71.96% with PPV of 87% is achieved. |

“Bayesian Detection Algorithm”

Bayesian detection algorithm is used [7] to classify the changes in retinal fundus image in order to diagnose the diabetic retinopathy. This method can detect brightness variation, fundus image artifacts, outliers, and segmentation errors. Segmentation of optical disk, blood vessels, and fovea is performed in order to detect variations in the fundus image.

| Advantages | The algorithm can successfully detect lesions, e.g., Microaneurysm, Exudates, and Cotton wool spots. |

IV. PROPOSED SYSTEM OVERVIEW

There are various methods used in process of detection of DR. Divide the process into three steps preprocessing, the Region Based Approach and DR detection or classification.

![Figure: - Overview of Diabetic Retinopathy Detection](image)

1) Pre-processing

The input of the automated system is color fundus retinal image which is taken from internet.

   a) Selecting the Region of Interest (ROI):
   The original retinal image is cropped to select the region of interest (ROI).

   b) Green plane extraction:
   a. Green plane is extracted and a series of morphological opening operations are applied.
   b. Erosion followed by dilation with a specific structuring element.
2) To detect the degenerated region (dark pixels) particle analysis is performed.

3) DR Detection or classification
The algorithm detects groups of damaged pixels in the macula region and evaluates the total damaged area in the macula from the color retinal images. The retinal fundus images present structural and impulsive noise.

V. CONCLUSION
This paper surveys and analyzes the automatic DR detection and diagnosis applied to human retinal fundus images as input and processes it to identify abnormalities based on aforementioned DR features and assess its severity. Here number of technologies developed for diabetic retinopathy (DR) has been studied. This survey revealed that a significant amount of efforts have been made on enhancing the image quality by optimizing image contrast and background illumination over green channel fundus images.

Thus, observing overall literatures and respective contributions, it can be visualized that evolutionary computing schemes can be of significance to strengthen all the comprising functional components of the diabetic retinopathy, including pre-processing by enhancing filters coefficient, segmentation by enriching clustering or ROI feature selection, feature extraction, feature selection, and dimensional reduction, and classification enhancement by facilitating optimal learning weight parameters regularization parameters (for SVM) etc.

REFERENCES


