Automatic Delineation of Retinal Area from SLO Images for Diagnosing Diabetic Retinopathy

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Abstract— Diabetic retinopathy is one of the leading impairing chronic diseases and one of the leading causes of preventable blindness in the world. Most of the ophthalmologist depends on the visual interpretation for the identification of Diabetic Retinopathy. But incorrect diagnosis will change the course of treatment planning which leads to fatal results. Hence there is a requirement for a impartial automated system which gives highly accurate results. Early diagnosis of diabetic retinopathy enables timely treatment. To achieve this a major effort will have to be invested into automated screening programs. For automatic screening programs to work vigorously efficient image processing and analysis algorithms have to be developed. Nowadays, Scanning laser ophthalmoscopes (SLOs) can be used for detection of retinal diseases. In this paper, we propose a novel framework for the extraction of retinal area of SLO images and diagnosis of retinal diseases from the retinal area using Support vector machine. The proposed method analyze the retinal images for important features of diabetic retinopathy using image processing techniques and an image classifier based on SVM which classify the images conforming to disease conditions. The main types of diabetic retinopathy are non-proliferative diabetic retinopathy (NPDR) and proliferative diabetic retinopathy (PDR).

Key words: Diabetic Retinopathy (DR), Gray level co-occurrence matrix (GLCM), Proliferative Diabetic Retinopathy (PDR), Non-proliferative diabetic retinopathy (NPDR), Super Pixels, Scanning Laser ophthalmoscope (SLOs), Simple linear Iterative clustering (SLIC), Support Vector Machine(SVM)

I. INTRODUCTION

The World Health Organization (WHO) recently indicated that there are about 135 million people in the world having diabetes mellitus and this number may go up to 300 million by 2025. There has been focus on methods and algorithms that would help experts in the medical fields to process digital inputs, analyze results and diagnose different illnesses. This approach is consisting of digital image studies with an aim of providing ways I n diagnosing the diabetic retinopathy and identifying the severity of the disease. It typically includes application of image processing on digital images of the retinal structures. Progress in this area has been achieved in recent times and improved medical care is available for the patients. According to a recent survey Diabetes has been recognized as the main cause of blindness. Early diagnosis through regular screening and timely treatment is essential to prevent visual lows and complete blindness. Diabetic is the major cause of blindness in patients between the age group of 30 to 60. Diabetic retinopathy is as complication of diabetic mellitus. Diabetic retinopathy produces large irregular hemorrhages which are difficult to diagnose. By seeing Fig1 one can understand the difference between image produced by normal eye and DR affected eye

Fig. 1: Normal eye and DR affected eye

A. *Different Types of Diabetic Retinopathy*

Diabetic Retinopathy can be classified in to two main types:

- Non proliferative diabetic retinopathy (NPDR)
- Proliferative diabetic retinopathy (PDR)

Diagnosis of Diabetic retinopathy is usually conducted by ophthalmologist by retinal images of patients. By using a Fundus camera or SLO, an ophthalmologist can obtain retinal images from patients diagnosed. This process is done manually by an ophthalmologist, it is very time consuming task. Computer analysis of retinal images can potentially reduce ophthalmologist work load and improves diagnosis efficiency

The 2-Dretinal sweeps acquired from scanning laser ophthalmoscope (SLO) might contain structures called artefacts other than retinal area. Removal of this artefacts (eyelashes, eyelids) is the preprocessing step before automated detection of features of retinal diseases.

In this paper we are proposing a novel framework for the extraction of retinal area of SLO images and automatically analyzing the severity of Diabetic retinopathy

The main steps of our frame work include:

- Determination of features that can be used to distinguish between the retinal area and the artefacts;
- Selection of features which are most relevant to the classifications;
- Constructions of the classifier which can classify out the retinal area from SLO images.
- Automatic classification of the images according to disease conditions.

B. *Anatomy of Eye*

The human eye is similar to a camera. Light that passes through the iris is focused onto the retina through a lens. There, the visual information is encoded and transmitted to the brain through the optical nerve. In fig.2 a cross section of the human eye is shown with the most important anatomy labeled. In this work the retina is the most important part of an eye. The specific changes caused by diabetic retinopathy can often be detected visually by examining the retina [9].

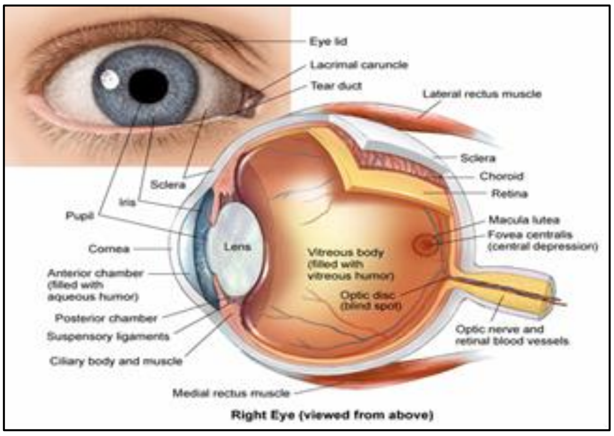

Fig. 2: Diagram of Anatomy of Eye

II. RELATED WORK

Automated image processing techniques have the ability in the early detection of diabetic retinopathy disease which can be regarded as a manifestation of diabetes on the retina. The automated way of such screening of digital images will help medical experts screen and diagnose a large population of patients. Over a period of last decade, there is a lot of research conducted by different experts and authors over automatic detection of diabetic retinopathy based on extraction of features of retinal images.

Maria Garcia et al [1] found that Diabetic retinopathy (DR) was an important cause of visual impairment in industrialized countries. Automatic detection of DR early markers can contribute to the diagnosis and screening of the disease. The aim of that study was to automatically detect one of such early signs: red lesions (RLs), like hemorrhages and micro aneurysms. To achieve that goal, they extracted a set of colour and shape features from image regions and performed feature selection using logistic regression, For neural network based classifiers were subsequently used to obtain the final segmentation if red lesions: multilayer perceptron (MLP), radial basis function (RBF), support vector machine (SVM) and a combination of those three NNs using a majority voting (MV) schema. Their data base was composed of 115 images. It was divided into a training set of 50 images (with RLs) and a test set of 65 images (40 with RLs and 25 without RLs). Attending to performance and complexity criteria, the best results were obtained for RBF.

Priya R and Aruna P, et al [2] stated that the automated analysis of human eye fundas image was an important task. Diabetes was a disease which occurs when the pancreas does not secrete enough insulin or the body was unable to process it property. That disease affects slowly the circulatory system including that of the retina. As diabetes progresses, the vision of a patient may start to deteriorate and lead to diabetic retinopathy. The main stages of diabetic retinopathy (PDR). In that paper, they have approached a computer based approach for the detection of DR stages using color fundus images. The features were extracted from the raw image, using the image processing techniques and fed to the Support Vector Machine (SVM) for classification. The results showed a sensitivity of 99.45 % for the classifier and Specificity of 100 %.

M S Haleem et al [3], stated that Glaucoma is a group of eye diseases that have common traits such as, high eye pressure, damage to the Optic Nerve Head and gradual vision loss. It affects peripheral vision and eventually leads to blindness if left untreated. The current common methods of pre-diagnosis of Glaucoma, which are performed manually by the clinicians. These tests are usually followed by Optic Nerve Head (ONH) Appearance examination for the confirmed diagnosis of Glaucoma. The diagnoses require regular monitoring, which is costly and time consuming. The accuracy and reliability of diagnosis is limited by the domain knowledge of different ophthalmologists. Therefore automatic diagnosis of Glaucoma attracts a lot of attention. This paper surveys the state-of-the-art of automatic extraction of anatomical features from retinal images to assist early diagnosis of the Glaucoma.

III. SYSTEM ANALYSIS

A. *Existing System*

The 2-D retinal scans obtained from imaging instruments may contain structures other than the retinal area. These structures other than the retinal area are collectively regarded as artefacts. Exclusion of artefacts is important as a preprocessing step before automated detection of features of retinal diseases. In a retinal scan, extraneous objects such as eyelashes, eyelids, and dust on optical surfaces may appear bright and in focus. Therefore automatic segmentation of these artefacts from an imaged retina is not a trivial task. The purpose of performing this study is to develop a method that can exclude artefacts from retinal scans so as to improve automatic detection of disease features from the retinal scans. In the existing system, the watershed based ANN classifier is used.

1) *Disadvantages*

- Therefore automatic segmentation of these artefacts from an imaged retina is not a trivial task.
- The purpose of performing this study is to develop a method that can exclude artefacts from retinal scans so as to improve automatic detection of disease features from the retinal scan.

B. *Proposed System*

Diabetic Retinal images used in the experiment is from Optos[4]. The main objective of the design is to define a testing protocol and database which can be used to benchmark diabetic retinopathy detection methods. All the images are captured by SLO. The SLO manufactured oby Optos [4] produces images of the retina with a width of up to 200°(measured from the center of the eye.

In this paper an automated approach for delineation of retinal area from SLO images for diagnosing diabetic retinopathy is presented. The evaluation of proposed automatic diagnosis system have been performed using a set of images which is a combination of normal, PDR, NPDR affected images. Simplified block diagram of proposed system is shown in Fig. 3 below.

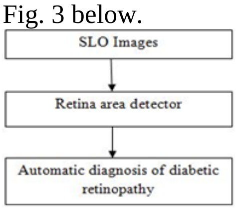

Fig. 3: Simplified Block Diagram

The SLO images first converted into superpixels using SLIC algorithm. Then features are calculated for each superpixel of the image present in the training set. In testing stage, only those features will be generated which are selected by feature selection process. The SVM classifier is used to detect the retinal diseases .Finally the images are classified into Normal, PDR and NPDR

IV. METHODOLOGY

Methods used in this project can be classified in two steps.

- Retina area detection from SLO images using SLIC and GLCM
- Diagnosis of diabetic retinopathy from extracted retinal area using SVM

A. Retina area detection from SLO images using SLIC and Gray Level Co-occurrence matrix (GLCM)

Various steps in the retina area detector is explained below

1) Collection Retina image and Image Data Integration

Diabetic Retinal image used in this experiment are from Optos[4]. All the images are captured by SLO. The SLO manufactured by Optos[4] produces images of retina with a width of upto 200° (measured from the centre of the eye). Image Data Integration involves the integration of image data with their manual annotation around true retinal area.

2) Image Pre processing

Pre-processing is the initial step in all case of image related diagnosis system and it helps in accurate feature extraction which ultimately results in high classification accuracy. Images are then preprocessed in order to bring the intensity values of each image in to a particular range.

3) Generation of Superpixels

The superpixel algorithm groups pixels into different regions, which can be used to calculate image features while reducing the complexity of subsequent image processing tasks. Superpixels capture image redundancy and provide a convenient primitive image pattern. The Superpixel generation method used in our retina detector frame work is simple linear iterative clustering [6]

4) Feature Generation

We generate image-based features using GLCM[7]. The Gray Level Co-occurence Matrix (GLCM) method is used for extracting Statistical Texture Parameters i.e., Entropy, Inverse Difference, Moment, Angular Second Moment and Correlation etc. These features are used to distinguish between the retinal area and the artefacts. The image-based features reflect textural, grayscale, or regional information and they were calculated for each superpixel of the image present in the training set. In testing stage, only those features will be generated which are selected by feature selection process.

5) Feature selection

Due to large number of features, the feature array needs to be reduced before classifier construction. This involves features selection of the most significant features for classification.

6) Classifier Construction

In conjunction with manual annotations, the selected features are then used to construct the binary classifier. The result of such a classifier is the superpixel representing either the true retinal area or the artefacts. SVM classifier used in our proposed retina detector framework.

SVM is a powerful method used for data classification and regression. The SVM methods are described in detail by Vapnik[8]. SVM model construct a hyper plane for separating the given data linearly into separate classes. Support vector machine method is used to distinguish between various classes. The training process analyses training data to find an optimal way to classify images into their respective classes. The training data should be sufficient to be statistically significant. The support vector machine algorithm is applied to produce classification parameters according to calculated features. The derived classification parameters are used to classify the images. The image content can be discriminated into various categories in terms of designed support vector classifier.

7) Image Post Processing

Image Post Processing is performed by morphological filtering so as to determine the retinal area boundary using superpixels classified by the classification model.

B. Diagnosis of diabetic retinopathy from extracted retinal area using SVM

Flow chart of automatic diagnosis of diabetic retinopathy is depicted in Fig. 4.

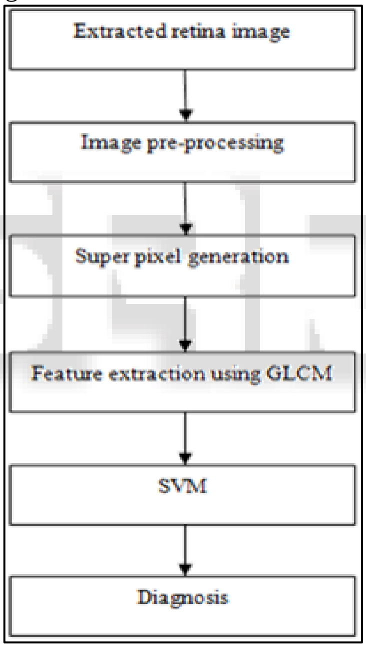

Fig. 4: Flow chart of automatic diagnosis of diabetic retinopathy

After extracting the retina area, next step is the automated diagnosis of diabetic retinopathy. Support vector machine is used for this classification. Support vector machine is a supervised learning process applied for analyzing the training data to find an optimal way to classify the diabetic retinopathy images into their respective classes namely PDR, NPDR or normal Extracted features is fed to the support vector machine algorithm to produce the classification parameters. The derived classification parameters are used to classify the images. The image content can be discriminated into various categories in terms of designed support vector classifier. To fit nonlinear curves to the data, SVM make use of a Kernel function to map the data into feature space where a hyper plane can be used to do separation.

V. Results and Discussion

The proposed diabetic retinopathy detection using SLIC and object classification with Support Vector Machine (SVM) was simulated using MATLAB. Typical color SLO image is given as the input. SVM is trained to detect whether the SLO image is healthy, non-proliferative diabetic retinopathy (NPDR) and proliferative diabetic retinopathy (PDR) as illustrated in fig. The proposed method has been verified by taking 30 patients images to detect the diabetic retinopathy.

A. Healthy Image

Fig. 5(a): Test Image

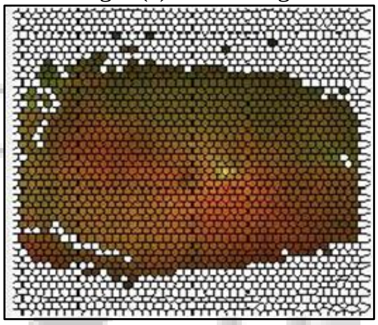

Fig. 5(b): Classifier

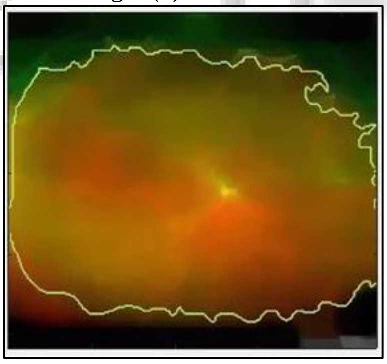

Fig. 5(c): Retina Area

B. Proliferative Diabetic Retinopathy (PDR)

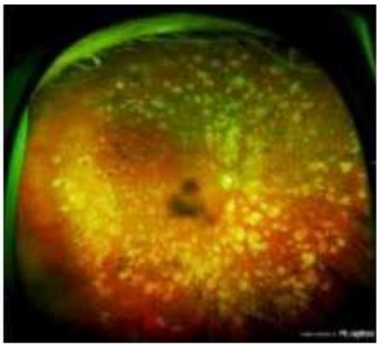

Fig. 6(a): Test Image

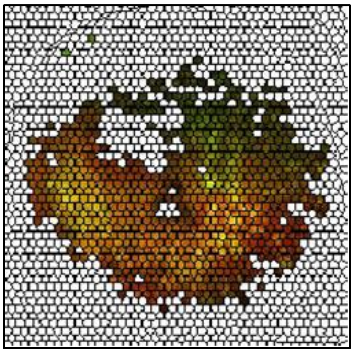

Fig. 6(b): Classifier

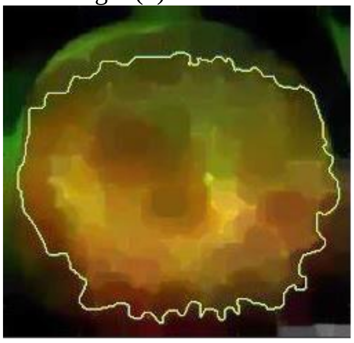

Fig. 6(c): Retina Area

C. Non Proliferative Diabetic Retinopathy (NPDR)

Fig. 7(a): Test Image

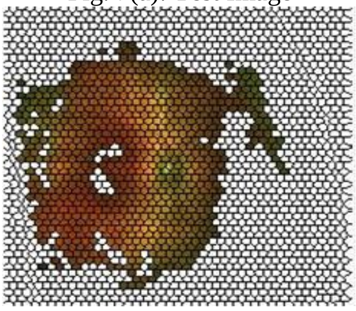

Fig. 7(b): Classifier

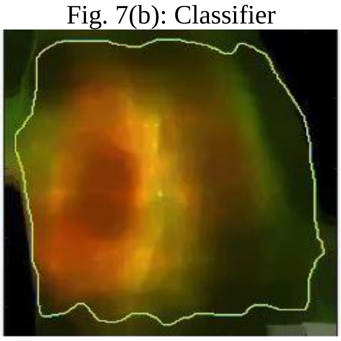

Fig. 7(c): Retina Area

Fig. 7: Result of three different cases of SLO images. examples of (a) test images (b) super pixel classification and (c) represent output after postprocessing

VI. CONCLUSION & FUTURE WORK

In the diagnosis of Diabetic Retinopathy, image processing of SLO images has an important role to play. The input color retinal images are poor quality. So Pre-process the image using a Gaussian Filter. The pre-processed images are then converted into super pixels. From the super pixels features were extracted for classification Process by GLCM. As, an achievement of this work, the DR has been classified into three categories, Healthy, NPDR, and PDR using SVM. Existing system use artificial neural network for classification. Speed of the neural network weight adjustment is slow, the convergence rate is rather slow and easy to fall into local minimum, but SVM is more efficient than ANN. Thus this work has given a successful Automatic detection of Diabetic Retinopathy method which helps to diagnose the disease in early stage which mutually reduces the manual work. The trial evaluation results exhibits our proposed frame work can finish a precision of 92%

In future in order to improve efficiency and better results I would like to employ below modifications in the project

- Increase size of test and training data set
- To use better morphological analysis algorithm to get clearer features.
- Implement neural nets in a better and efficient way

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