Qualitative, Quantitative and Comparative Analysis of Diabetic Eye Classifier

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Abstract— Diabetic eye screening is a key part of diabetes care. People with diabetes are at risk of damage from diabetic retinopathy, a condition that can lead to sight loss if it is not treated. It occurs when diabetes affects small blood vessels, damaging the part of the eye called the retina. When the blood vessels in the central area of the retina (the macula) are affected, it's known as diabetic retinopathy. This project presents a method for detection and classification of exudates in colored retinal images. It eliminates the replication exudates region by removing the optic disc region. Several image processing techniques including Image Enhancement, Segmentation, Classification, and registration has been developed for the early detection of DR on the basis of features such as blood vessels, exudes, haemorrhages and micro aneurysms. This project presents a review of latest work on the use of image processing techniques for DR feature detection.

Key words: Dynamic Shape Features, Retina, Retinopathy Screening, Lesion Detection

I. INTRODUCTION

Feature extraction starts from an initial set of measured data and builds derived values intended to be informative and non-redundant, facilitating the subsequent learning and generalization steps, and in some cases leading to better human interpretations. Feature extraction is related to dimensionality reduction. Lesion may be hardly visible in areas of poor contrast and/or low brightness. The RGB to Gray scale conversion is done to increase the dynamic range of the image. It damages the retinal blood vessels. Microaneurysms (MA)[1], a bright lesion which present in the retina is the first visible sign that indicates the presence of the disease .DR can have classified into two types: (1) Non-Proliferative Diabetic retinopathy. (The occurrence can be noted in the vision's central part and swelling of macula) (2) Proliferative Diabetic retinopathy (anomalous growth of blood vessels in the retina and the gel- like fluid fills the eye and finally it harms the entire part of the eye).

A. *Diabetic Retinopathy (DR)*

Diabetic Retinopathy (DR) is an eye disease associated with long-standing diabetes. Around 40% to 45% of Americans with diabetes have some stage of the disease. Progression to vision impairment can be slowed or averted if DR is detected in time; however this can be difficult as the disease often shows few symptoms until it is too late to provide effective treatment.

Digital colour fundus photographs of the retina. By the time human readers submit their reviews, often a day or two later, the delayed results lead to lost follow up, miscommunication, and delayed treatment.

The early stage of this disease is called non-proliferative diabetic retinopathy. In this stage blood vessels swell and sometimes bulge or balloon (aneurysm). The vessels may leak fluid that can build up in the retina and cause swelling. This condition is called macular edema, and it changes the vision of individuals with the disease [2]. The blurriness is sometimes compared to trying to look through water.

Proliferative diabetic retinopathy an advanced form of diabetic retinopathy occurs when abnormal new blood vessels and scar tissue form on the surface of the retina.

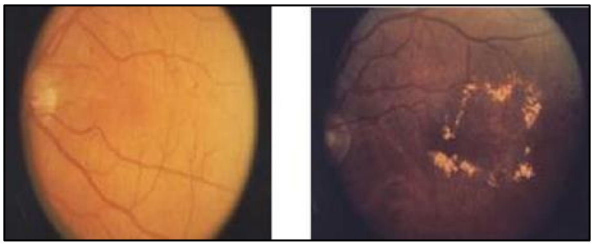

Fig. 1: Surface of the retina

The Age-Related macular degeneration (AMD) is the most common cases in hospitals. It related to Aging, the person who has crossed the years of 50, will have the chance of AMD [4]. There is no complete solution for this disease but regular monitoring and regular treatment can slow down the progression. AMD is of two types: dry and wet AMDs [5].Dry type MD is the major cause for development of macular degeneration. It can be identified initially by the Occurrence of yellow pigmentation and the pattern of drusen. Ophthalmologists can manually inspect the formation of AMDs. It happens by the fluids which present in our eyes can fill the retina. Laterally, it starts bleeding and leads to vision loss. When it was examined, immediately it has to be treated by laser. Approximately 10% of all people will have the Wet Type AMD. The Winconsin AMD grading system classifies drusen based on dimension and visibility of the boundary [6]. It can be classified into two types: Hard drusen and soft drusen. The retinal lesion can be detected and categorize into two hyper-pigmentation and hypo-pigmentation. During the inspection of AMD, the features has to extracted are drusen, retinal pigmentation and Geographic Atrophy (GA)[7]. Many researches had come up with several segmenting methods for drusen, a preliminary step in the classification of AMD.

B. *Diabetic Retinopathy*

DR occurs due to the complications in the diabetes. It affects 50% of all Americans with diabetes. It happens when the retinal blood vessel gets swell and starts bleeding by rupturing the vessels. In 2011, International Diabetes Federation (IDF) reported that, diabetes diagnosed in 366 million people and it will reach to 520 million in 2030. Diabetes can contract with any disease and it can increase the rigorousness of that disease and it majorly affect the eyes of the people which leads to DR. It damages the retinal blood vessels. Microaneurysms (MA)[1], a bright lesion which present in the retina is the first visible sign that indicates the presence of the disease .DR can have classified into two types: (1) Non- Proliferative Diabetic retinopathy. (The occurrence can be noted in the vision's central part and swelling of macula) (2) Proliferative Diabetic retinopathy (anomalous growth of blood vessels in the retina and the gel-like fluid fills the eye and finally it harms the entire part of the eye).

C. Stages of DR

Diabetic Retinopathy can be classified into five stages based on the level of lesion identified:

1) Mild Non-Proliferative retinopathy: Presence of tiny swellings in the retina.
2) Moderate Non-proliferative retinopathy: As the disease improves, blockage in some of the blood vessels of the retina can occur.
3) Severe Non-proliferative retinopathy: If the blood vessels get blocked, there will be no supply of blood to the retina and it leads to signs of ischemia (lack of oxygen).
4) Proliferative Diabetic retinopathy: It is the advanced progression of the disease wherein the enormous blood vessel growth can occur.
5) Macular Edema: The size of the retina will differ when compared to the normal one.

The paper describes the previous research work carried out based on various algorithm proposed for automatic detection of diabetic retinopathy and detectors available for feature extraction.

II. Related works

A. Automatic Detection of DR

Decision Support system for the detection of diabetic retinopathy [8] has been designed for opthalmologists, general practitioners, emergency room physicians, and other healthcare personal alike. Machine learning techniques and sophisticated image analysis were used to propose a decision support system which is low cost and portable smart-phone based to initially screen the signs of DR. A smartphone has to be attached to a direct hand held ophthalmoscope. It is used to capture fundus images to detect the pathologies as seen through the direct ophthalmoscope and applies pattern recognition and statistical inference algorithms to facilitate decision making for the initial assessment of DR.

Geetha Ramani[9] proposed a novel computational approach for automatic disease detection that utilizes retinal image analysis and data mining techniques to accurately categorize the retinal images as Normal, Diabetic retinopathy and glaucoma affected the system comprises of two phases: the training phase and the test phase. The former involves fundus image preprocessing, measurement calculations, feature relevant analysis followed by generation of calculation rules that constitutes the knowledge base. The algorithm used in this paper C4.5 (Decision) algorithm and Randoim tree algorithm.

W.Mimi Diyana and W. Zaki[10] presented a general overview of the grading assessment system for DR. It shows the advantages of automated detection system and the risk factors in manual checking. The automated system allows to identify the early signs of diabetic retinopathy and the blocks in retinal vessels. Tortuosity of the blood vessels is introduced as one of the significant features that can be quantified and associated with DR stages for the grading assessment. DR screening has utilized a number of different examination methods, namely using slit lamp bio-microscopy, direct or indirect ophthalmoscopy, and mydriatic (dilated) and non-mydriatic (non-dilated) digital fundus photography. The UK National Institute for Clinical Excellence (NICE) recommends that DR screening modalities should have a sensitivity of at least 80% and a specificity of at least 95%. The Early Treatment Diabetic Retinopathy Study (ETDRS) classification syatem is the gold standard used in clinical trials, which classifies DR into seven stages: None, Minimal NPDR, Mild NPDR, Moderate NPDR, Severe NPDR, PDR and High Risk PDR K.Zutis and E.Trucco [11] presented a prototype image processing system for detecting abnormal retinal capillary regions in ultra-wide field-of-view (UWFOV) fluorescein angiography exams of human retina. The UWFOV frame can be taken as the input for the algorithm and returns the identified candidate as the output. It used the image analysis algorithm and its works by Canny edge extraction at multiple scales within a sliding window approach. It used the LibSVM Matlab SVM library for classification.

B. Algorithms for Image Mining

An Apriori algorithm to mine the examination records ofreferral patients was proposed by Gwenole Quellec and Mathieu Lamard [12]. It has been designed to learn the characterization of fungus images and to diagnosing rules to mine multiple examination records. The author used BoVW to detect the frequent patterns identified in retinal fundus images. These patterns are then related to a visual word. Histogram characterizes that region and rules were extracted. G.Kavitha[13] proposed a hybrid approach to analyse optic disc and macula to characterise the normal and abnormal status of the retina. The retinal images can be taken as input for the ant colony optimization algorithm. It is then pre-processed. Typical original retinal images, Otsu, ACO and combined Otsu-ACO acquired through examination. The ACO performs the operation of Optic Disc (OD) detection. Further the Otsu method considered for the detection of assumptive macular area of macula. Otsu method combined with ACO to detect the macula. It is also possible to extract useful features such as optic disc radius, fovea radius and distance between centres of the macula and optic disk for classification. Ahmed Zikri Rozlan and Hadzli Hashim [14] proposed a system that can help ophthalmologists to perform early screening on diabetes patients. The method to detect exudate consists of two steps: rough and fine exudate segmentation. The image can be pre-processed followed by the analysis of retinal images. At the end of the Pre-processing step Optic disc has been removed. OD usually occupies approximately one seventh of the entire image, and is part of the retina which has the highest intensity value. The next step followed is exudate segmentation where the rough and fine exudates were segmented. DR severity index was calculated using a per-pixel basis. The extracted features from the statistical outcomes which represent the confidence interval for each stage of DR were then employed at the classifier stage of the system.

C. Detectors used in Feature Extraction

Rodrigo Veras and Romuere Silva [15] introduced a computer- aided diagnosis system that can identify patients who present risk of vision loss and require greater assistance for a Specialist. It applies the Speed-Up Robust Feature (SURF) algorithm to find points of interest to form visual dictionaries. Visual Dictionaries can represent all feature vectors generated by the SURF descriptor as a feature vector. It gets the original image as input and identifies the SURF points by assigning a attriobute value for each points. Classification process has been performed by following the Image signature assigned to attribute vector. K-means clustering algorithm is used to assemble the dictionary word. Finally, the images can be classified as healthy and pathological ones by using the SURF descriptor. Ethan Rublee and Vincent Rabaud[16] proposed a very fast binary descriptor based on BRIEF(Bimary robust independent Elementary Features) called ORB, which is rotation invariant and resistant to noise. It demonstrates that how ORB has faster magnitude than SIFT (Scale-Invariant Feature Transform) while performing as well as in many situations. FAST (Fast from Accelerated Segment Test) detector is used to identify the interest points in an image. B.Nayebifar and H. Abrishami Moghaddam [17] presented a new approach based on particle filtering to determine and locally track the vessel paths in the retina. The red lesions are micro aneurysms and haemorrhages; here the micro aneurysms (MN) are detected to diagnose the diabetic retinopathy.

Only the micro aneurysms are detected and not haemorrhages (HE).Only the part of image is processed to detect the lesions. Watershed segmentation reduces the actual size of the candidate objects. In this approach, most of the false positive results occur at the vessel segmentation step.

III. Proposed System

In this method the colour fundus image is taken as input together with the binary mask of its region of interest (ROI).

The method comprises six steps

- Spatial Calibration: Spatial calibration refers the process of correlating the pixels of an acquired image to real features in the image. This process can be used to make accurate measurements in real-world units (instead of pixels), and to correct for camera perspective and lens distortion.
- Image Pre-processing: Lesion may be hardly visible in areas of poor contrast and/or low brightness. The RGB to Gray scale conversion is done to increase the dynamic range of the image [4].
- Optical Disc Removal: The optic disc is considered one of the main features of a retinal image, where methods are described for its automatic detection. The detection of optic disc is a key pre-processing component in many algorithms designed for the automatic extraction of retinal anatomical structures and lesions [3].
- Candidate Extraction: Feature extraction starts from an initial set of measured data and builds derived values intended to be informative and non-redundant, facilitating the subsequent learning and generalization steps, and in some cases leading to better human interpretations. Feature extraction is related to dimensionality reduction.

A. Dynamic shape Features

Shape Features involved reducing the amount of resources required to describe a large set of data. When performing The Age-Related macular degeneration (AMD) is the most common cases in hospitals. It related to Aging, the person who has crossed the years of 50, will have the chance of AMD [4]. There is no complete solution for this disease but regular monitoring and regular treatment can slow down the progression. AMD is of two types: dry and wet AMDs [5]. Dry type MD is the major cause for development of macular degeneration. It can be identified initially by the Occurrence of yellow pigmentation and the pattern of drusen. Ophthalmologists can manually inspect the formation of AMDs. It happens by the fluids which present in our eyes can fill the retina. Laterally, it starts bleeding and leads to vision loss. When it was examined, immediately it has to be treated by laser. Approximately 10% of all people will have the Wet Type AMD. The Winconsin AMD grading system classifies drusen based on dimension and visibility of the boundary [6]. It can be classified into two types: Hard drusen and soft drusen. The retinal lesion can be detected and categorize into two hyper-pigmentation and hypo-pigmentation. During the inspection of AMD, the features has to extracted are drusen, retinal pigmentation and Geographic Atrophy (GA)[7]. Many researches had come up with several segmenting methods for drusen, a preliminary step in the classification of AMD. . It gets the original image as input and identifies the SURF points by assigning an attribute value for each points. Classification process has been performed by following the Image signature assigned to attribute vector. K-means clustering algorithm is used to assemble the dictionary word. Finally, the images can be classified as healthy and pathological ones by using the SURF descriptor. Ethan Rublee and Vincent Rabaud [16] proposed a very fast binary descriptor based on BRIEF (Bimary robust independent Elementary Features) called ORB, which is rotation invariant and resistant to noise. The paper describes the previous research work carried out based on various algorithm proposed for automatic detection of diabetic retinopathy and detectors available. A smartphone has to be attached to a direct hand held ophthalmoscope. It is used to capture fundus images to detect the pathologies as seen through the direct ophthalmoscope and applies pattern recognition and statistical inference algorithms to facilitate decision making for the initial assessment of DR. Geetha Ramani [9] proposed a novel computational approach for automatic disease detection that utilizes retinal image analysis and data mining techniques to accurately categorize the retinal images as Normal, Diabetic retinopathy and glaucoma affected. The system comprises of two phases: the training phase and the test phase. The former involves fundus image preprocessing, measurement calculations, feature relevant analysis followed by generation of calculation rules that constitutes the knowledge base. The algorithm used in this paper C4.5 (Decision) algorithm and Randoim tree algorithm. W.Mimi Diyana and W. Zaki[10] presented a general overview of the grading assessment system for DR. It shows the advantages of automated detection system and the risk factors in manual checking. The automated system allows to identify the early signs of diabetic retinopathy and the blocks in retinal vessels. Tortuosity of the blood vessels is introduced as one of the significant features that can be quantified and associated with

DR stages for the grading assessment. DR screening has utilized a number of different examination methods, namely using slit lamp bio-microscopy, direct or indirect ophthalmoscopy, and mydriatic (dilated) and non-mydriatic. The method to detect exudate consists of two steps: rough and fine exudate segmentation. The image can be pre-processed followed by the analysis of retinal images. At the end of the Pre- processing step Optic disc has been removed. OD usually occupies approximately one seventh of the entire image, and is part of the retina which has the highest intensity value. The next step followed is exudate segmentation where the rough and fine exudates were segmented. DR severity index was calculated using a per-pixel basis. The extracted features from the statistical outcomes which represent the confidence interval for each stage of DR were then employed at the classifier stage of the system. International Diabetes Federation (IDF) reported that, diabetes diagnosed in 366 million people and it will reach to 520 million in 2030. Diabetes can contract with any disease and it can increase the rigorousness of that disease and it majorly affect the eyes of the people which leads to DR. It damages the retinal blood vessels and micro aneurysms from the damaged retina the next step followed is exudate segmentation where the rough and fine exudates

Analysis of complex data one of the major problems stems from the number of variables involved.

- Classification: The classification of DR falls into two classes Non-proliferative (Normal blood vessels) and proliferative (Abnormal blood vessel growth).

The proposed system contains twophases: 1) Training phase and 2) Testing phase. In training phase the images can be taken as input for the system and it should be in a JPEG format.

B. Training Phase

1) Preprocessing

The retinal images from the data repository has to be processed as the initial step by extracting the background pixels. Normally, the fundus images are stored as RBG (red, blue and green components) in hospital database. Detecting the presence of abnormal pathologies in retina is a very crucial part because of the disputes like luminosity, brightness, color contrast and noise.

2) Feature Extraction

Optic disc, exudates, macula and fovea are the features needed to be extracted from every fundus image. KFCM algorithm and Curvelet Transform are used to extract the Optic Disc and the blood vessels through non-linear mapping. The best approach for extracting the vessels is matched filter also been employed.

3) Clustering

Segmented features are then applied for clustering to group the fungus images as per lesions detected. K-means clustering algorithm is used to cluster the identified items and it relocates to the corresponding group. At the end of the training phase, all the inputs in the dataset will be clustered according to the type of lesion identified.

4) Retinal vessel tortuosity

To measure the vessel tortuosity it uses the Arc-to chord ratio, which is the simplest method.

It is defined by, the total length of the vessel arc,L divided with the shortest length/distance between the chord end points (A &B), or simply $\lambda(s)$. It can be represented by,

$$\tau(s)=L/\lambda(s) \quad (1)$$

C. Testing Phase

1) Detectors

Detectors are used for the accurate detection of lesions type. SIFT and SURF are the best detectors and descriptors. SIFT provides the key points that matches the similar objects whereas the SURF forma a circular region around the key point and it describes the type of lesion accurately.

2) Classification

All the detected fundus images are then now classified using a classifier named Apriori algorithm. It splits the data to all the nodes for classifying the stage of disease. If any node takes longer time to complete one task, then it sends the remaining tasks to one of the nodes which is completed the tasks. This algorithm helps to classify the images into four stages like Normal, Mild, Moderate and Severe. The performance of our system can be measured by calculating the specificity, sensitivity and accuracy.

IV. Implementation

A. Image Acquisition

The image is fetched from gallery that is required for further processing.

B. Pre-processing obtain

Image enhancement technique is used to obtain the required visual quality of image.

- Gray scale image.
- Filtered image.
- Histogram Equalization image.

C. Image Segmentation

Image segmentation is the process of partitioning a digital image into multiple segments [5].

The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze.

- Morphological Operation
- Thresholding Methods

D. Feature Extraction

Feature extraction starts from an initial set of measured data and builds derived values intended to be informative and non-redundant, facilitating the subsequent learning and generalization steps, and in some cases leading to better human interpretations. Feature extraction is related to dimensionality reduction.

E. Classification

The classification process is done over the segmented images. The main novelty here is adoption of Random Forest.

V. Conclusion

The results demonstrate the strong performance of the proposed method in detecting both MA's and HE's in Fundus images of the different resolution and quality and from different acquisition system. In many of the hospitals, the examinations of Diabetic Retinopathy detection carried out only through the standard ETDRS systems which can be examined manually. Automatic detection will reduce the time and makes the process simpler for both doctor and the patient. In our work, a system is designed to automatically detect Diabetic Retinopathy by training and testing the fundus images. Though, the severity of this disease leads to loss of vision, the only way to prevent it by early treatment.

But it does not show any early signs and symptoms to Detect. The fundus photographs have to be taken using Ophthalmoscopy and it can be processed using the automatic detection system. The detector SIFT is used for the accurate detection of pathologies and it classified using the well-known appropriate algorithm. It produces the result into four stages as normal, mild, moderate and severe. The performance of the system is measured by calculating the specificity, sensitivity and accuracy.

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