A Segmentation Improved Statistical Model for Retinal Disease Identification

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Abstract

Retinal images are analyzed to identify the glaucoma or the diabetic disease. The accuracy of disease detection depends on the extracted features. In this paper, segmentation and mathematical filters based statistical approach is presented to identify the retinal disease. At first stage of this statistical model, the features from retinal image are extracted using segmentation method. This segmentation model is able to separate the disc and cup features. Later on the ratio analysis between cup and disc is considered to identify the chances of retinal disease. The experimentation is applied on real time images. The results shows that the work has provided effective identification of retinal disease.
Keywords: Glaucoma, retinal ganglion cells (RGC), optic nerve head (ONH), cupping

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I. INTRODUCTION

To perform the medical image processing and disease detection, a series of image processing operations are required to improve quality of acquired image and to perform the detection. These processing stages are given here under:

A. Enhancement:
Medical images are often deteriorated by noise due to interference and other phenomena that affect the imaging processes. Image enhancement is the improvement of image quality to increase the perception of information in images for medical specialists.

B. Noise Suppression:
Suitable noise suppressing algorithm is selected based on what type of noise presented in the image. Impulse noise (having distribution of extreme values, only isolated pixels are affected) should be removed by Mean or Median filter. Narrowband noise (a few strong frequency components form the noise) is suppressed by removing false frequency coefficients from the discrete two-dimensional spectrum and reconstructing the image from the new spectral information.

C. Sharpening:
Enhancing the sharpness by accentuating edges may contribute to raise more visible details in an image. Laplacian, Sobel, Robert Cross are some algorithms used to extract edges and thus increase the sharpness of the image.

D. Contrast Enhancement:
The appearance of an image depends significantly on the image contrast. There are three contrast enhancement methods: Linear contrast adjustments, nonlinear contrast adjustments (the brightness mapping is described by linear or nonlinear functions) and histogram equalization (changing pixel intensities so that the histogram is optimized with respect to even distribution).

E. Image Segmentation:
The goal of image segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. Image Segmentation is the process of partitioning a digital image into multiple regions or sets of pixels .Actually, partitions are different objects in image which have the same texture or color. The result of image segmentation is a set of regions that collectively cover the entire image, or a set of contours extracted from the image. All of the pixels in a region are similar with respect to some characteristic or computed property, such as color, intensity, or texture. Adjacent regions are significantly different with respect to the same characteristics. The goal of image segmentation is to cluster pixels into salient image regions, i.e., regions corresponding to individual surfaces, objects, or natural parts of objects. Segmentation could be used for object recognition, occlusion boundary estimation within motion or stereo systems, image compression, image editing, or image database look-up. The concept of Watersheds is well known in topography. It is a morphological based method of image segmentation. Segmentation using the watershed transforms works well if you can identify, or "mark," foreground objects and background locations.

1) *Retinal Disease Prediction*

Retinal Disease detection locates and segments Retinal Disease regions from cluttered images, either obtained from video or still image. It has numerous applications in areas like surveillance and security control systems, content based image retrieval, video conferencing and intelligent human computer interface. Most of the current Retinal Disease recognition systems presume that retinal disease is readily available for processing. However, we do not typically get images with just Retinal Disease. We need a system that will segment Retinal Disease in cluttered images. With a portable system, we can sometimes ask the user to pose for the Retinal Disease identification task. In addition to creating a more cooperative target, we can interact with the system in order to improve and monitor its detection. With a portable system, detection seems easier. The task of retinal disease detection is seemingly trivial for the human brain, yet it still remains a challenging and difficult problem to enable a computer /mobile phone/PDA to do Retinal Disease detection. This is because the human Retinal Disease changes with respect to internal factors like Retinal Disease expression, beard, mustache glasses etc and it is also affected by external factors like scale, lightening conditions, and contrast between Retinal Disease, background and orientation of Retinal Disease.

Retinal Disease detection remains an open problem. Many researchers have proposed different methods addressing the problem of Retinal Disease detection. In a recent survey Retinal Disease detection technique is classified into feature based and image based. The feature based techniques use edge information, skin color, motion and symmetry measures, feature analysis, snakes, deformable templates and point distribution. Image based techniques include neural networks, linear subspace method like Eigen Retinal Disease, fisher Retinal Disease etc. The problem of Retinal Disease detection in still images is more challenging and difficult when compared to the problem of Retinal Disease detection in video since emotion information can lead to probable regions where Retinal Disease could be located.

2) *Medical Image Processing*

Medical image processing and analysis is a technique and science to detect degenerated tissue. The main advantage of medical imaging is to make diagnosis as possible as noninvasive way in the treatment planning and clinically diagnosis. There are various types of medical imaging technologies based on noninvasive approach like Computed Tomography (CT), Magnetic Resonance Imaging (MRI) and X-Ray etc.MRI is best suitable high quality medical imaging technology rather than others to collect perfect internal information of the body organ for clinical diagnosis. Medical imaging is a field in which researches develop tools to acquire, manipulate and achieve digital images that are used to provide better care for the patients. In medical science the problem as well as the data stream is three-dimensional and the effort to solve the problem is mostly combination of both human and machine.

Medical tasks can often be split into three areas:

- Data operations like filtering, noise removal, and contrast and feature enhancement
- Detection of medical conditions and events
- Qualitative analysis of the lesion or detected events.

3) *Glaucoma Disease*

Glaucoma is a progressive degeneration of retinal ganglion cells (RGC) and their axons, resulting in a distinct appearance to the optic nerve head (ONH), often called ‘cupping’ . Glaucoma leads to visual disability. This damage also leads to improper functioning of drainage system of eye leading to increased intra-occular pressure. This IOP leads to full or partial loss of vision. It also results in change in shape of optic disk leading to increased cup to disk ratio. Glaucoma is the third leading cause of blindness, yet amongst those with the disease it is relatively rare to be registered blind according to World Health Organization criteria, as central vision is often preserved until late in the disease despite disabling loss of peripheral vision and the damage to the visual field is irreversible; however, if the disease is detected at its early stage, it can be treated. If the condition is left untreated the damage to the affected visual field usually worsens and spreads until eventually complete loss of vision can occur.

II. Review of Literature

In Year 2002, Jim Beach performed a work," Spectral Reflectance Technique for Retinal Blood Oxygen Evaluation in Humans". Author present spectral reflectance curves obtained with a prism-grating-prism (PGP) spectrographic camera from structures producing hemoglobin signatures, including the retinal artery and vein, the pigmented retina and the optic disk, as well as from the macular area which is free of this signature. Oxygen-dependent changes in the hemoglobin signature are determined from vessels and tissue surround.

In Year 2006, Kevin Noronha performed a work," Enhancement of retinal fundus Image to highlight the features for detection of abnormal eyes". This paper describes the methods to detect main features of fundus images such as optic disk, fovea, and exudates and blood vessels. To determine the optic Disk and its centre Author find the brightest part of the fundus and apply Hough transform.

In Year 2007, Sangyeol Lee performed a work," Validation of Retinal Image Registration Algorithms by a Projective Imaging Distortion Model". A variety of methods for retinal image registration have been proposed, but evaluating such methods objectively is difficult due to the lack of a reference standard for the true alignment of the individual images that make up the montage. Author also presents the validation tool for any retinal image registration method by tracing back the distortion path and accessing the geometric misalignment from the coordinate system of reference standard.

In Year 2008, S. Sekhar performed a work," automated localization of retinal optic disk using hough transform". The retinal fundus photograph is widely used in the diagnosis and treatment of various eye diseases such as diabetic retinopathy and glaucoma. The proposed method consists of two steps: in the first step, a circular region of interest is found by first isolating the brightest area in the image by means of morphological processing, and in the second step, the Hough transform is used to detect the main circular feature.

In Year 2010, Michael D. Abràmoff performed a work," Retinal Imaging and Image Analysis". Methods for 2-D fundus imaging and techniques for 3-D optical coherence tomography (OCT) imaging are reviewed. Special attention is given to quantitative techniques for analysis of fundus photographs with a focus on clinically relevant assessment of retinal vasculature, identification of retinal lesions, assessment of optic nerve head (ONH) shape, building retinal atlases, and to automated methods for population screening for retinal diseases.

In year 2009, Riries Rulaningtyas and Khusnul Ain defined a work of edge detection for Glaucoma detection detection. In this work Glaucoma diagnosis is done by doctors. For detecting Glaucoma grading always gives different conclusion between one doctor to another. For helping doctors diagnose Glaucoma grading, this research made a software with edge detections method , so it could give edge pattern of Retinal and Glaucoma itself. Edge detection of Glaucoma in this research is the first step for Glaucoma grading research. This research found the best edge detection method for Glaucoma detecting between Robert, Prewitt, and Sobel method. From these three methods, Sobel method is suitable with case of Glaucoma detecting. Sobel method had smaller deviation standard value than two others edge detection method.

In year 2010, Ehab F. Badran, Esraa Galal Mahmoud, and Nadder Hamdy defined a new algorithm to detect the barin infection. In this paper, a computer-based method for defining infection region in the Retinal using MRI images is presented. A classification of Retinal into healthy Retinal or a Retinal having a infection is first done which is then followed by further classification into beginning or malignant infection. The algorithm incorporates steps for preprocessing, image segmentation, feature extraction and image classification using neural network techniques. Finally the infection area is specified by region of interest technique as confirmation step. A user friendly Matlab GUI program has been constructed to test the proposed algorithm

In year 2010, N. Nandha Gopal, Dr. M. Karnan defined a work on Glaucoma detection using C Means clustering algorithm. In this paper an intelligent system is designed to diagnose Glaucoma through MRI using image processing clustering algorithms such as Fuzzy C Means along with intelligent optimization tools, such as Genetic Algorithm (GA), and Particle Swarm Optimization (PSO). The detection of infection is performed in two phases: Preprocessing and Enhancement in the first phase and segmentation and classification in the second phase.

In Year 2011, Zafer Yavuz performed a work," RETINAL BLOOD VESSEL SEGMENTATION USING GABOR FILTER AND TOPHAT TRANSFORM". In this paper, Author suggests a method to segment retinal blood vessels automatically. In the method, Author applies top-hat transform after Gabor filter to enhance blood vessels. Later on, the output of the transformation is converted to binary image with p-tile thresholding.

In Year 2012, K.Sangeetha performed a work," Advanced Analysis of Anatomical Structures Using Hull Based Neuro-Retinal Optic Cup Ellipse Optimization in Glaucoma Diagnosis". This research relies on the problem of detecting those abnormalities in the eye of a diabetic patient for the earlier detection of DR. Here a methodology is presented for the automatic detection of the blood vessels and abnormalities in the eye of diabetic patients using digital image processing algorithm (DIP).

In Year 2012, R. Geetha Ramani performed a work," Automatic Prediction of Diabetic Retinopathy and Glaucoma through Retinal Image Analysis and Data Mining Techniques". In this paper, a novel computational approach for automatic disease detection is proposed that utilizes retinal image analysis and data mining techniques to accurately categorize the retinal images as Normal, Diabetic Retinopathy and Glaucoma affected.

In Year 2012, Kumar Parasuraman, has defined a work on “Automated Detection of Diseases by Nicking Quantification in Retinal Images”. This paper proposes a novel technique that collects information about all blood vessels that present in the retinal image and identifies the true vessel in a retinal image. In the proposed method, first the input image is choose and the blood vessels are segmented. From that the crossover point detection is applied to detect the vessels which are crossing each other by using the window with the neighboring pixels.

III. PROBLEM DEFINITION

Image Processing is having its significance in the medical imaging to identify and classify the various diseases. To identify these diseases, it is required to extract the various features over the images and to perform the feature selection and separation so that the disease classification will be done. Eye or retinal image processing is one of such effective area having its significance to recognize the diabetes or glaucoma over the images. The identification of retinal cup size and its ratio analysis under blood vessel variation is effective to identify the disease over the images. The recognition accuracy is always a challenge in this area. In this work, a segmentation improved curvature analysis approach is defined to perform the recognition of glaucoma over the medical images. The work is here divided in two main stages. In first stage, the segmentation over the image will be performed to extract the blood vessel features analysis. Once the feature will be identified, the block wise region analysis will be applied to identify the retinal cup. Here the statistical measurement will be performed to identify chances of disease in patient. The work is about to improve the recognition rate. The work is implemented in matlab environment.

IV. FLOW CHART USED

The presented work is about the detection of retinal Glaucoma disease in optical retinal images. To perform this detection a two stage approach is presented, in first stage, the extraction of ROI will be done using intelligent segmentation algorithm and in second stage, the curvature analysis approach will be used to identify the blood vessel and cup. The work is about to identify the retinal disease more accurately.

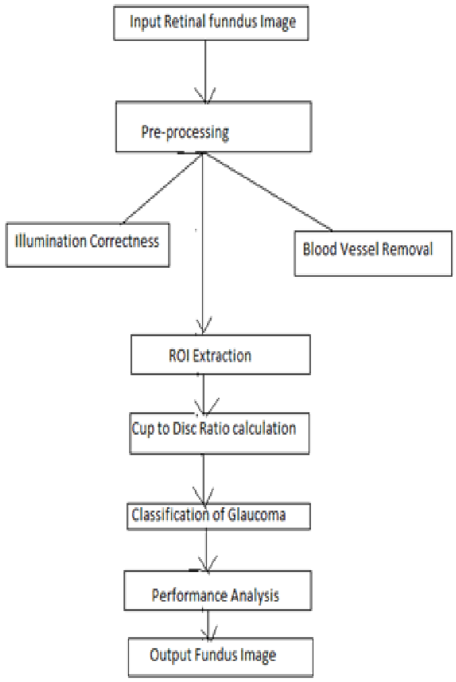

Fig. 1: Proposed Methodology for Detection of Glaucoma

Our methodology includes following steps:

- Data Acquisition
- Preprocessing
- Processing
- Classification or Segmentation
- Analysis of result

The preprocessing work includes the conversion of image to the normalized image as well as to extract the features from the image. The filtration process includes the adjustment of brightness, contrast, low pass, high pass filtration etc. The filtration will be done in two phases one for Iris and other for eye. Once the filtration process is done extraction of Iris and eye will be performed. Just after extraction process the feature extraction will be done. These featured images are the main input image to the system.

A. Steps Involved In the Methodology

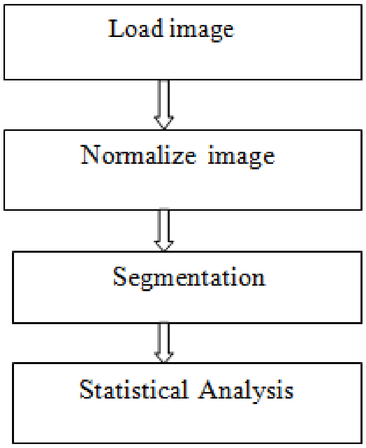

Fig. 2: steps used

1) *Load Image*

Select an image for the identification of true blood vessels in the retinal images and to characterize them.

2) *Normalize Image*

In image processing, normalization is a process that changes the range of pixel intensity values. Applications include photographs with poor contrast due to glare, for example. Normalization is sometimes called contrast stretching or histogram stretching. In more general fields of data processing, such as digital signal processing, it is referred to as dynamic range expansion.

The purpose of dynamic range expansion in the various applications is usually to bring the image, or other type of signal, into a range that is more familiar or normal to the senses, hence the term normalization. Often, the motivation is to achieve consistency in dynamic range for a set of data, signals, or images to avoid mental distraction or fatigue.

Normalization transforms an n-dimensional grayscale image:

$$I : \{\mathbb{X} \subseteq \mathbb{R}^n\} \rightarrow \{\text{Min}, .., \text{Max}\}$$

With intensity values in the range (Min,Max), into a newimage

$$I_N : \{\mathbb{X} \subseteq \mathbb{R}^n\} \rightarrow \{\text{newMin}, .., \text{newMax}\}$$

with intensity values in the range (newMin,newMax).

Color image of diseased/normal eye is converted into grey scale image from the red channel for the detection of optical disk and from the green channel for the detection of optical cup. The grey scale image is filtered and normalize.

3) *Segmentation*

Image segmentation is the process of partitioning a digital image into multiple segments (sets of pixels, also known as superpixels). 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. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain characteristics.

Automated blood vessel segmentation is an important issue for assessing retinal abnormalities and diagnosis of many diseases. The segmentation of vessels is complicated by huge variations in local contrast, particularly in case of minor vessels. The appearance and structure of blood vessels play an important role in diagnosis of eye diseases. Change in retinal blood vessel features are precursors of serious diseases. Therefore analysis of retinal vascular features can assist in detecting these changes and allow the patient to take action while the disease is still in its early stage.

The normalized image is converted to binary based on threshold value. Based on threshold value selection optical disk (OP) and optical cup (OC) will be selected.

4) *Analysis*

After segmentation is performed, then connect all pixels to produce regular regions or blobs. This process is exhaustive and can affect the real time performance. The threshold values have a large influence on the segmentation results. A small threshold value leads to a large number of small regions while with a large threshold value few large regions are calculated.

Finally, validate the Retinal Disease detection and position in the frame by polling. Simply, then examine all the regions, and if there is a region common to at least three colors spaces, then considered such region as the detected Retinal Disease, in the other way, if the mentioned condition is not satisfied, the region is discarded and the process is performed to the next region or the next frame.

V. EXPERIMENTAL RESULTS

The proposed method is implemented in MATLAB software, which provides an easy way to implementation. The step by step process of the proposed method is shown below:

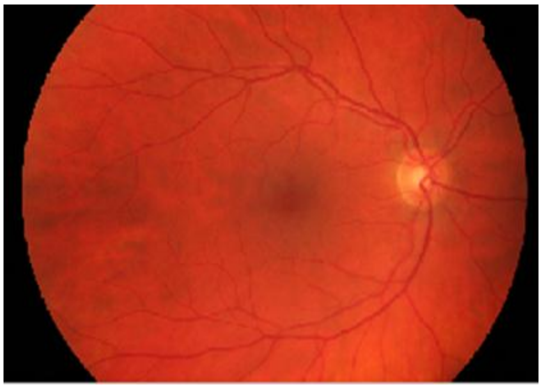

Fig. 3: Selected retinal image

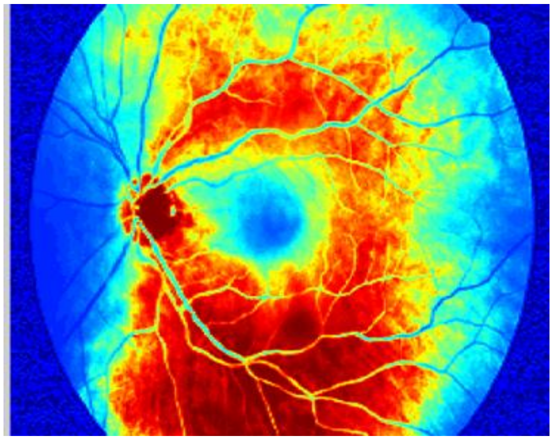

Fig. 4: Final result image

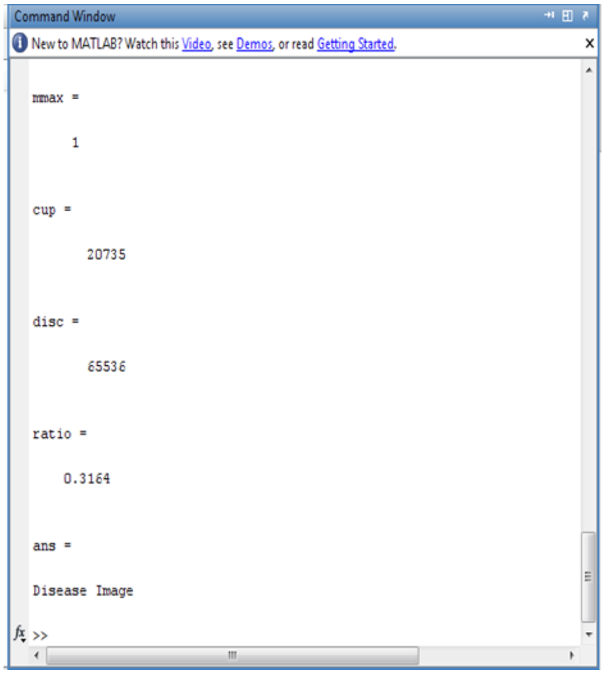

Fig. 5: result showing diseased image

1) Dataset I

Properties	*Values*
Number of Images	*10*
Type	*Color*
Format	*Jpg*
Resolution	*3504x2336*
Number of Images Correctly Recognized	*8*
Recognition Ratio	*80%*

Image name	*Cup size*	*Disc size*	*ratio*	*result*
01_dr.JPG	*22049*	*65536*	*0.3364*	*Normal image*
02_g.jpg	*20735*	*65536*	*0.3164*	*Diseased image*
03_h.jpg	*21390*	*65536*	*0.3264*	*Diseased image*
04_dr.jpg	*21708*	*65536*	*0.3312*	*Normal image*
05_dr.JPG	*21229*	*65536*	*0.3239*	*Diseased image*
06_g.jpg	*21754*	*65536*	*0.3319*	*Normal image*
07_g.jpg	*21253*	*65536*	*0.3243*	*Diseased image*
08_dr.jpg	*21129*	*65536*	*0.3224*	*Diseased image*
09_dr.jpg	*21602*	*65536*	*0.3296*	*Diseased image*
10_g.jpg	*21881*	*65536*	*0.3339*	*Normal image*

VI. CONCLUSION

In this paper, a mathematical model is presented to identify the retinal disease. The mathematical analysis is here implied to generate the image features and to recognize the disease. At the earlier stage, the segmentation is defined using clustering approach and morphological operators. The analytical results obtained from the work in terms of detection ratio. The result shows that the work has provided the effective identification rate.

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