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Retinal Image Processing Using Neural Networks for Disease Prediction

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ABSTRACT: Diabetic retinopathy (DR) is a serious eye disease originating from diabetes mellitus and the most common cause of blindness in the developed countries. Early treatment can prevent patients to become affected from this condition or at least the progression of DR can be slowed down. The key to the early detection is to recognize microaneurysms (MAs) in the fundus of the eye in time. Thus, mass screening of diabetic patients is highly desired, but manual grading is slow and resource demanding. Microaneurysms (MAs) are early signs of DR, so the detection of these lesions is essential in an efficient screening program to meet clinical protocols. Early micro aneurysm detection can help reduce the incidence of blindness and Micro aneurysm detection is the first step in automated screening of diabetic retinopathy. A reliable screening system for the detection of MAs on digital fundus images can provide great assistance to ophthalmologists in difficult diagnoses. This project presents image processing techniques such as dark object detection to analyze the condition or enhance the input image in order to make it suitable for further processing and improve the visibility of Microaneyrysm in color fundus images. The correlation coefficient between each processed profile and a typical microaneurysm profile is measured and used as a scale factor to adjust the shape of the candidate profile. Each candidate is then classified based on spread spectrum analysis features. We implement this retinal imaging in real time environments.

KEYWORDS: Computer-aided diagnosis, image classification, microaneurysm detection, retinal image, singular spectrum analysis, diabetic retinopathy.

I. INTRODUCTION

The major objectives of the proposed system are summarized below: (A) Since the retina is vulnerable to microvascular changes of diabetes and diabetic retinopathy is the most common complication of diabetes, eye fundus imaging is considered a noninvasive and painless route to screen and monitor such diabetic eyes, (B) Diabetic retinopathy (DR) is the most common diabetic eye disease, (C) Diabetic Retinopathy is a medical condition where the retina is damaged because fluid leaks from blood vessels into the retina. In extreme cases, the patient will become blind, (D) So, early microaneurysms (MAs) detection and diabetic retinopathy (DR) is important in avoiding vision loss, (E) Since the presence of micro aneurysms (MAs) is usually the first sign of DR and occurs due to blood vessel damage in the retina, (F) Early MAs can help to reduce the incidence of blindness and it is the first step in automated screening of Diabetic retinopathy and (G) The presences of MAs in the retina are the earliest symptoms of DR. In imaging science, image processing is processing of images using mathematical operations by using any form of signal processing for which the input is an image, a series of images, or a video, such as a photograph or video frame; the output of image processing may be either an image or a set of characteristics or parameters related to the image.

Most image-processing techniques involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to it. Images are also processed as three-dimensional signals with the third-dimension being time or the z-axis. Image processing usually refers to digital image processing, but optical and analog

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image processing also are possible. This article is about general techniques that apply to all of them. The acquisition of images (producing the input image in the first place) is referred to as imaging. Closely related to image processing are computer graphics and computer vision. In computer graphics, images are manually made from physical models of objects, environments, and lighting, instead of being acquired (via imaging devices such as cameras) from natural scenes, as in most animated movies.

Computer vision, on the other hand, is often considered high-level image processing out of which a machine/computer/software intends to decipher the physical contents of an image or a sequence of images (e.g., videos or 3D full-body magnetic resonance scans). In modern sciences and technologies, images also gain much broader scopes due to the ever growing importance of scientific visualization (of often large-scale complex scientific/experimental data).

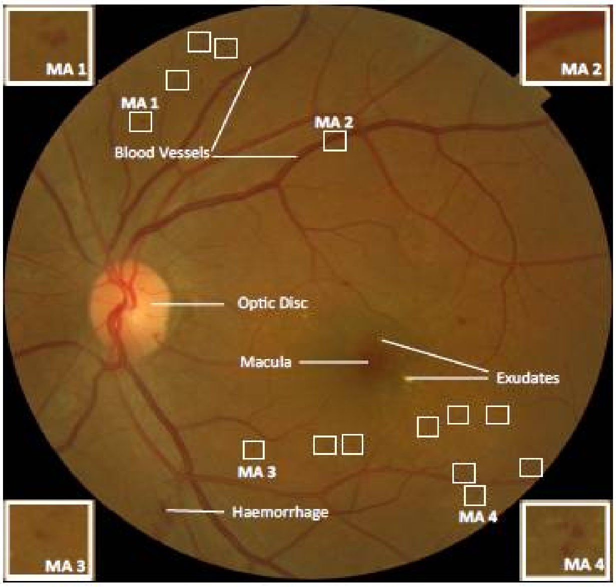

Fig.1 An instance of digital fundus image containing both anatomic structures (Optic Disc, Macula and Blood Vessels) and pathological signs of DR (MAs, Haemorrhage and Exudates). White boxes indicate some of the MAs.

Examples include microarray data in genetic research, or real-time multi-asset portfolio trading in finance. Image analysis is the extraction of meaningful information from images; mainly from digital images by means of digital image processing techniques. Image analysis tasks can be as simple as reading bar coded tags or as sophisticated as identifying a person from their face. Computers are indispensable for the analysis of large amounts of data, for tasks that require complex computation, or for the extraction of quantitative information. On the other hand, the human visual cortex is an excellent image analysis apparatus, especially for extracting higher-level information, and for many applications — including medicine, security, and remote sensing — human analysts still cannot be replaced by computers. For this reason, many important image analysis tools such as edge detectors and neural networks are inspired by human visual perception models.

Image editing encompasses the processes of altering images, whether they are digital photographs, traditional photochemical photographs, or illustrations. Traditional analog image editing is known as photo retouching, using tools such as an airbrush to modify photographs, or editing illustrations with any traditional art medium. Graphic software programs, which can be broadly grouped into vector graphics editors, raster graphics editors, and 3D modelers, are the primary tools with which a user may manipulate, enhance, and transform images. Many image editing programs are also used to render or create computer art from scratch. Raster images are stored in a computer in the form of a grid of

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picture elements, or pixels. These pixels contain the image's color and brightness information. Image editors can change the pixels to enhance the image in many ways. The pixels can be changed as a group, or individually, by the sophisticated algorithms within the image editors. This article mostly refers to bitmap graphics editors, which are often used to alter photographs and other raster graphics. However, vector graphics software, such as Designer, Editor, Inscape or Vector, are used to create and modify vector images, which are stored as descriptions of lines, Bezier curves, and text instead of pixels.

It is easier to rasterizing a vector image than to victories a raster image; how to go about vector zing a raster image is the focus of much research in the field of computer vision. Vector images can be modified more easily, because they contain descriptions of the shapes for easy rearrangement. They are also scalable, being rasterizable at any resolution. Many graphics applications are capable of merging one or more individual images into a single file. The orientation and placement of each image can be controlled. When selecting a raster image that is not rectangular, it requires separating the edges from the background, also known as silhouetting. This is the digital analog of cutting out the image from a physical picture.

Clipping paths may be used to add silhouetted images to vector graphics or page layout files that retain vector data. Alpha compositing, allows for soft translucent edges when selecting images. There are a number of ways to silhouette an image with soft edges, including selecting the image or its background by sampling similar colours, selecting the edges by raster tracing, or converting a clipping path to a raster selection. Once the image is selected, it may be copied and pasted into another section of the same file, or into a separate file. The selection may also be saved in what is known as an alpha channel. A popular way to create a composite image is to use transparent layers. The background image is used as the bottom layer, and the image with parts to be added are placed in a layer above that. Using an image layer mask, all but the parts to be merged are hidden from the layer, giving the impression that these parts have been added to the background layer. Performing a merge in this manner preserves all of the pixel data on both layers to more easily enable future changes in the new merged image.

II. EXISTING APPROACHES – A SUMMARY

Diabetic retinopathy can be broadly classified as non proliferative diabetic retinopathy diabetic patient’s retina is very important. And, automated or computer assisted analysis of diabetic patients retina can help eye care specialist to screen larger populations of patients. With a large number of patients, the workload of local ophthalmologists is highly unsubstantial. So the automated detection systems should be able to limit the severity of the disease and pave assistance to the ophthalmologists in diagnosing and remedying the disease, effectively. To build such automated systems, different modules are needed for analyzing retinal anatomical features such as fovea, optic disc, blood vessels, and common diabetic pathologies, such as hemorrhages, micro aneurysms, and exudates. One of the most important steps in the automated detection of DR is the detection of microaneurysms.

Microaneurysms are amongst the earliest observable signs of the presence of diabetic retinopathy. Due to a large number of patients, the available ophthalmologists are not sufficient in handling all the patients, especially in rural areas. Therefore, automated early detection of microaneurysms could ease the burden of ophthalmologists. Automated microaneurysms detection can also help the ophthalmologists in investigating and treating the disease more efficiently. The feature selection and exudates classification using naive bayes and Support Vector Machine (SVM) Classifiers.

At first, they used naive bayes model to a training set consisting of 15 features extracted from positive and negative examples of exudates pixels. Next, to obtain the best SVM, they used the best feature set from the naive bayes classifier and continually appended the removed features to the classifier. For each combination of features, they carried out a grid search to find the best combination of hyper parameters like tolerance for training error and radial basis function width. The existing system has lots of disadvantages, some of them are described below: (a) Computational complexity is high, (b) Need hardware to diagnosis the disease, (c) Segmentation accuracy is less and (d) Fault tolerance can be occurred.

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III. PROPOSED SYSTEM SUMMARY

Diabetes is a well-known disease that may cause abnormalities in the retina (diabetic retinopathy) and nervous system (diabetic neuropathy). Also diabetes can make a major risk for cardiovascular diseases. Diabetic retinopathy is a micro vascular complication caused by diabetes which can lead to blindness in the working age population. Blood vessels providing blood supply to the retina when blood vessels gradually weaken due to diabetes, it can be swelled and blocked. The disordered and weak small blood vessels are not able to maintain the right blood supply, they can be burst, and thereby exudates and blood can leak out to the vitreous part. The blood flown to vitreous part obstructs the path of light to the retina, thereby worsens vision. Diabetic retinopathy is one of the leading disabling diseases in eye; it will be leading causes of preventable blindness in the world. Early diagnosis of diabetic retinopathy enables timely treatments.

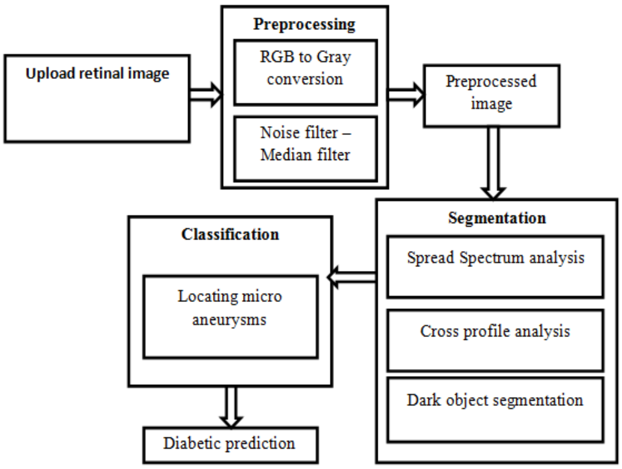

Fig.2 Proposed System Architecture

In order to achieve this major concern will have to be invested into automated screening programs. For automated screening programs of diabetic retinopathy, image processing and analysis algorithms have to be developed. Candidate objects are first located by applying a dark object filtering process. Then singular spectrum analysis process detects the Microaneurysm. Any object in the image showing MA-like characteristics then Candidate extraction process identifies such characteristic. These candidates will then be further analyzed or classified into MAs and non-MAs using filtering process. The methods are able to extract isolated MAs away from other dark objects including vessels. However, when an MA is next to other dark objects, it was often not detected but considered as part of the neighboring objects.

Calculate its eight neighboring pixels have lower or the same intensity. Here the pixel regarded to be a local maximum (in an inverted image), if the use of these local maxima made it easier to find out more MAs. And to implement the attain detection of Microaneurysm. multilayered dark object filtering method reduce common interfering structures as MA candidates such as vessel crossings as well as many small background regions due to high local intensity variation. The proposed system has lots of advantages; some of them are described below: (a) Time can be reduced at the time of prediction, (b) Segmentation accuracy is improved, (c) Eliminate irrelevant features and (d) Accurate classifier for diabetics.

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IV. SYSTEM IMPLEMENTATION

The proposed system is designed with lots of purposeful modules that are described in detail:

A. Image Acquisition

This is the first step or process of the fundamental steps of digital image processing. Image acquisition could be as simple as being given an image that is already in digital form. Generally, the image acquisition stage involves preprocessing, such as scaling etc.

B. Image Enhancement

Image enhancement is among the simplest and most appealing areas of digital image processing. Basically, the idea behind enhancement techniques is to bring out detail that is obscured, or simply to highlight certain features of interest in an image. Such as, changing brightness and contrast etc.

C. Image Restoration

Image restoration is an area that also deals with improving the appearance of an image. However, unlike enhancement, which is subjective, image restoration is objective, in the sense that restoration techniques tend to be based on mathematical or probabilistic models of image degradation.

D. Color Image Processing

Color image processing is an area that has been gaining its importance because of the significant increase in the use of digital images over the Internet. This may include color modeling and processing in a digital domain etc.

E. Wavelets and Multi-resolution Processing

Wavelets are the foundation for representing images in various degrees of resolution. Images subdivision successively into smaller regions for data compression and for pyramidal representation.

F. Compression

Compression deals with techniques for reducing the storage required to save an image or the bandwidth to transmit it. Particularly in the uses of internet it is very much necessary to compress data.

G. Morphological Processing

Morphological processing deals with tools for extracting image components that are useful in the representation and description of shape.

H. Segmentation

Segmentation procedures partition an image into its constituent parts or objects. In general, autonomous segmentation is one of the most difficult tasks in digital image processing. A rugged segmentation procedure brings the process a long way toward successful solution of imaging problems that require objects to be identified individually. Segmentation is a classifier which helps to fragment each character from a word present in a given image or page. The objective of the segmentation is to extract each character from the text present in the image. After performing Segmentation, the characters of the string will be separated and it will be used for further processing. Different character segmentation techniques has been proposed until like, Dissection Techniques, Recognition Based Hidden Markov Models and Non-Markov Approaches, Holistic Strategies. By dissection is meant the decomposition of the image into a sequence of sub images using general features. The structure consists of a set of states plus transition probabilities between states. A method stemming from concepts used in machine vision for recognition of occluded objects. A holistic process recognizes an entire word as a unit.

I. Representation and Description

Representation and description almost always follow the output of a segmentation stage, which usually is raw pixel data, constituting either the boundary of a region or all the points in the region itself. Choosing a representation is

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only part of the solution for transforming raw data into a form suitable for subsequent computer processing. Description deals with extracting attributes that result in some quantitative information of interest or are basic for differentiating one class of objects from another. Object recognition: Recognition is the process that assigns a label, such as, "vehicle" to an object based on its descriptors. Knowledge Base: Knowledge may be as simple as detailing regions of an image where the information of interest is known to be located, thus limiting the search that has to be conducted in seeking that information. The knowledge base also can be quite complex, such as an interrelated list of all major possible defects in a materials inspection problem or an image database containing high-resolution satellite images of a region in connection with change-detection applications.

J. Feature Extraction

In pattern recognition and in image processing, feature extraction is a special form of dimensional reduction. Transforming the input data into the set of features is called feature extraction. If the features extracted are carefully chosen it is expected that the features set will extract the relevant information from the input data in order to perform the desired task using this reduced representation instead of the full size input.

K. Retinal Imaging

Retinal imaging is a recent technological advancement in eye care. It enables optometrist to capture a digital image of the retina, blood vessels and optic nerve located at the back of eyes. This aids in the early detection and management of diseases that can affect both eyes and overall health. This includes glaucoma, macular degeneration, diabetes and hypertension. With retinal imaging technology, the most subtle changes to the structures at the back of eyes can be detected. Vascular Diseases are often life-critical for individuals, and present a challenging public health problem for society. The drive for better understanding and management of these conditions naturally motivates the need for improved imaging techniques.

Eye fundus is the interior surface of the eye, opposite to the lens and includes the retina, optic disc, macula and fovea and posterior pole. It is the only part of the human body where the micro circulation can be observed directly. It can be examined by ophthalmoscope or fundus photography. In a new unsupervised fuzzy algorithm for vessel tracking that is applied to the detection of the ocular fundus vessels. It overcomes the problems of initialization and vessel profile modelling that are encountered in the literature and automatically tracks fundus vessels using linguistic descriptions like "vessel" and "non-vessel." The main tool for determining vessel and non-vessel regions along a vessel profile is the fuzzy C-means clustering algorithm that is fed with properly reprocessed data. Additional procedures for checking the validity of the detected vessels and handling junctions and forks are also presented.

And then implemented a semi-automatic method to measure and quantify geometrical and topological properties of continuous vascular trees in clinical fundus images is described. Measurements are made from binary images obtained with a previously described segmentation process.

The skeletons of the segmented trees are produced by thinning, branch and crossing points are identified and segments of the trees are labeled and stored as a chain code. The operator selects a tree to be measured and decides if it is an arterial or venous tree. An automatic process then measures the lengths, areas and angles of the individual segments of the tree. Geometrical data and the connectivity information between branches from continuous retinal vessel trees are tabulated. A number of geometrical properties and topological indexes are derived. Implement automate segmentation approach based on spread spectrum method to provide regional information using width of the dark objects. The segmented dark objects as a segment graph and formulate the problem of identifying location as one of finding the microaneurysms in the graph given a set of constraints. These measurements are found to have good correlation with diabetics. However, they require the accurate extraction of distinct location from a retinal image. To solve this optimization problem and evaluate it on a large real-world dataset of retinal images.

V. LITERATURE SURVEY

In the year of 2010, the authors "M. D. Abramoff, J. M. Reinhardt, S. R. Russell, J. C. Folk, V. B. Mahajan, M. Niemeijer, and G. Quellec" proposed a paper titled "Automated early detection of diabetic retinopathy", in that they described such as: DR detection algorithms achieve comparable performance to a single retinal expert reader and are

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close to mature, and further measurable improvements in detection performance are unlikely. For translation into clinical practice sooner rather than later, validation on well-defined populations of patients with diabetes, with variable metabolic control and racial and ethnic diversity.

In the year of 2013, the authors "I. Lazar and A. Hajdu" proposed a paper titled "Retinal microaneurysms detection through local rotating cross-section profile analysis", in that they described such as: after the cross-sectional scanning and peak detection steps are performed for every scan direction on a given candidate, we calculate several statistical measures of the resulting directional peak properties.

In the year of 2014, the authors "C. Pereira, D. Veiga, J. Mahdjoub, Z. Guessoum, L. Gonc¸alves, M. Ferreira, and J. Monteiro" proposed a paper titled "Using a multi-agent system approach for microaneurysms detection in fundus images", in that they described such as: a new, small, red-lesion segmentation algorithm, based on a MAS approach, was proposed in this study. Through agent local interaction, the improvement of traditional algorithm results was possible, primarily by the detection of MAs close to vessels. The addition of a validation step through a local feature analysis allowed the reduction of the average number of FP and encourages the inclusion of some agent learning capacity for future improvement of the algorithm.

VI. EXPERIMENTAL RESULTS

The following figure shows the Image Selection option of the proposed system.

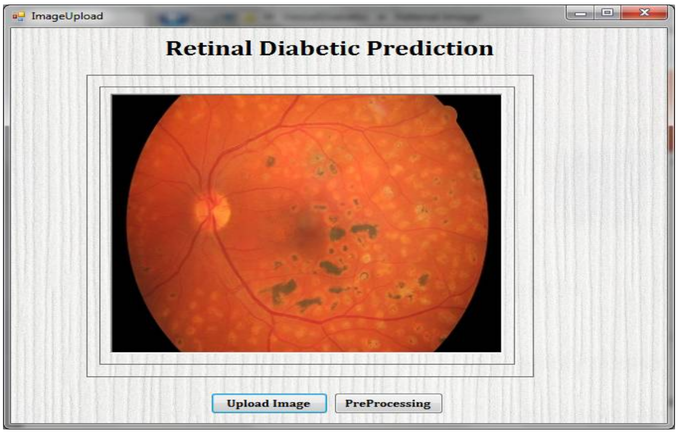

Fig.3 Image Upload/Selection Option

The following figure illustrates the Pre-Processing Scheme of the proposed system.

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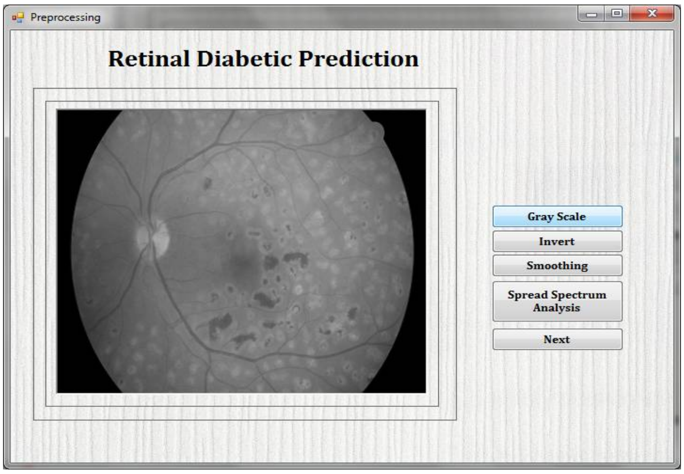

Fig.4 Pre-Processing

The following figure illustrates the Locating Microaneurysms of the proposed system.

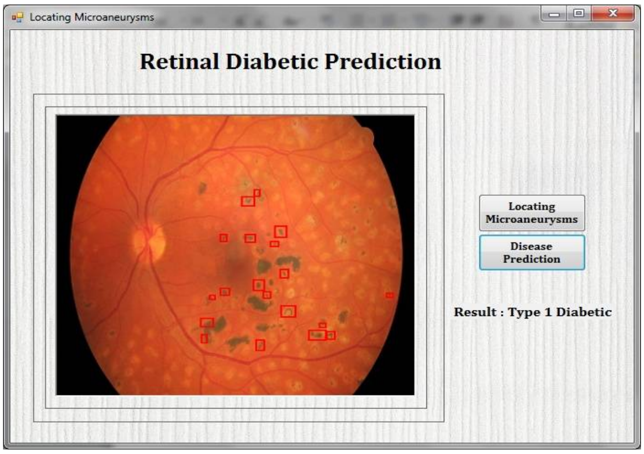

Fig.5 Locating Microaneurysms

VII. CONCLUSION

Diabetic retinopathy cannot be cured. To prevent vision loss, laser analysis (photocoagulation) is usually very effective if it is done before it adversely harms the retina. Provided that the stern destruction of retina has not been done, vision can be improved by the surgical elimination of vitreous gel (vasectomy). In proliferative diabetic retinopathy, at times, an anti-inflammatory medicine or anti-vascular endothelial growth factor medication injection can help in the new blood vessels contraction process. Since symptoms cannot build up until the disease turns into the stern, initial discovery via regular screening is essential. Non proliferative diabetic retinopathy contains early indications of DR and it is extremely critical to recognize and analyze DR at its initial stages. If a person with diabetes gets legitimate eye mind consistently and treatment when fundamental, DR will once in a while cause all out blindness. Proposed MA detection achieved a good sensitivity and specificity on a per image basis. This is especially meaningful when this method is integrated into a reliable automated system for detecting abnormality in digital fundus images. The proposed

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candidate filtering process is able to significantly reduce the number of non-MA candidates and sufficiently extract more candidates located close to the vasculature. We take the advantage of a basic SSA method to filter MA candidates' profiles.

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