RESEARCH ARTICLE OPEN ACCESS

Segmentation of Blood Vessels and Optic Disc in Fundus Images

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Abstract:

Diabetic retinopathy also known as diabetic eye disease, is when damage occurs to the retina due to diabetes. It can eventually lead to blindness. By analyzing and detecting vasculature structures in retinal image the diabetes can be detected in advanced stages by comparing its states of retinal blood vessels. In blood vessel classification approach computer based retinal image analysis can be used to extract the retinal image vessels. Stationary wavelet transform (SWT) are used to extract the features from the fundus image and classification can be performed using Support Vector Machine(SVM). SVM has become an essential machine learning method for the detection and classification of particular patterns in medical images. It is used in a wide range of applications for its ability to detect patterns in experimental databases. If the vessels are present, then it is extracted by using segmentation. Mathematical morphology and K-means clustering is used to segment the vessels. To enhance the blood vessels and suppress the background information, smoothing operation can be performed on the retinal image using mathematical morphology. Then the enhanced image is segmented using K-means clustering algorithm to detect the diseases easily.

***Keywords* — Vasculature, Vessel Segmentation, Mathematical Morphology, Clustering, Dilation, Erosion, Support Vector Machine (SVM), Stationary Wavelet Transform(SWT).**

I. INTRODUCTION

Manipulating data in the form of an image through several possible techniques. An image is usually interpreted as a two-dimensional array of brightness values, and is most familiarly represented by such patterns as those of a photographic print, slide, television screen, or movie screen. An image can be process adoptically or digitally with a computer. To digitally process an image, it is first necessary to reduce the image to a series of numbers that can be manipulated by the computer. Each number representing the brightness value of the image at a particular location is called a picture element, or pixel. A typical digitized image may have 512 × 512 or roughly 250,000 pixels, although much larger images are becoming common. Once the image has been digitized, there are three basic operations that can be performed on it in the computer. For a point operation, a pixel value in the output image depends on a single pixel value in the input image. For local operations, several neighbouring pixels in the input image determine the value of an output image pixel. In a global operation, all of the input image pixels contribute to an output image pixel value.

These operations, taken singly or in combination, are the means by which the image is enhanced, restored, or compressed. An image is enhanced when it is modified so that the information it contains is more clearly evident, but enhancement can also include making the image more visually appealing. An example is noise smoothing. To smooth a noisy image, median filtering can be applied with a 3 × 3 pixel window. This means that the value of every pixel in the noisy image is recorded, along with the values of its nearest eight neighbors. These nine numbers are then ordered according to size, and the median is selected as the value for the pixel in the new image. As the 3 × 3 window is moved one pixel at a time across the noisy image, the filtered image is formed. Another example of enhancement is contrast manipulation, where each pixel's value in the new image depends solely on that pixel's value in the old image; in other words, this is a point operation. Contrast manipulation is commonly performed by adjusting the brightness and contrast controls on a television set, or by controlling the exposure and development time in printmaking. Another point operation is that of pseudo coloring a black-and-white image, by assigning arbitrary colors to the gray levels. This technique is popular in thermography, where hotter objects are assigned one color and cool objects are assigned another color with other colors assigned to intermediate values.

The aim of restoration is also to improve the image, but unlike enhancement, knowledge of how the image was formed is used in an attempt to retrieve the ideal image. Any image-forming system is not perfect, and will introduce artifacts into the final image that would not be present in an ideal image. A point spread function, called a filter, can be constructed that undoes the blurring. By imaging the blurred image with the filter point spread function, the restored image results.

The filter point spread function is spread out more than the blurring point spread function, bringing more pixels into the averaging process. This is an example of a global operation, since perhaps all of the pixels of the blurred image can contribute to the value of a single pixel in the restored image. This type of deblurring is called inverse filtering, and is sensitive to the presence of noise in the blurred image. By modifying the deblurring filter according to the properties of the noise, performance can be improved. Compression is a way of representing an image by fewer numbers, at the same time minimizing the degradation of the information contained in the image.

Compression is important because of the large quantities of digital imagery that are sent electronically and stored. Digital high-definition television relies heavily on image compression to enable transmission and display of large-format color images. Fig. 1 shows the architecture of image processing system which performs image acquisition, storage, preprocessing, segmentation, representation, recognition, interpretation and finally displays or records the resulting image.

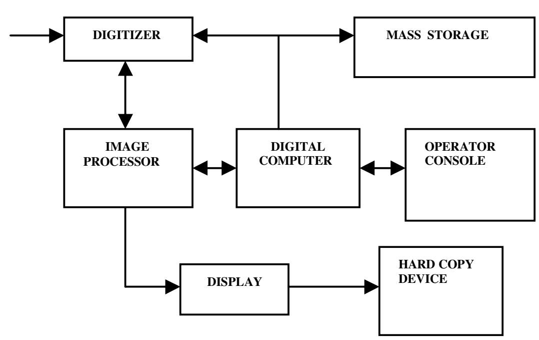

Fig. 1 Image Processing System

A digitizer converts an image into a numerical representation suitable for input into a digital computer. An image processor does the functions of image acquisition, storage, preprocessing, segmentation, representation, recognition, interpretation and finally displays or records the resulting image. Mathematical processing of the digitized image such as convolution, averaging, addition, subtraction, etc. are done by the computer. A digital computer is the most commonly used type of computer and is used to process information with quantities using digits, usually using the binary number system. An example of a digital computer is a MacBook.

The secondary storage devices normally used are floppy disks, CD ROMs etc. It refers to storage of large amount data in a persisting machine readable fashion. Modern *mass storage* devices include all types of disk drives and tape drives. The hard copy device is used to produce a permanent copy of the image for the storage of the software involve. A *hard copy* is a printed *copy* of information from a computer. The operator console consists of equipment and arrangements for verification of intermediate results and for alteration in the software as and when require. The operator is also capable of checking for any resulting errors and for the entry of requisites data.

II. RELATED WORKS

In [1] Abrmoff .D.M, Garvin .K.M, and Sonka .M proposes a new 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. The aspects of image acquisition, image analysis, and clinical relevance are treated.

In [2] Fraz .M, Remagnino .P, Hoppe .A, Uyyanonvara .B, Rudnicka .A, Owen .C, and Barman .S presented an ensemble system of bagged and boosted decision trees and utilizes a feature vector based on the orientation analysis of gradient vector field, morphological transformation, line strength measures, and Gabor filter responses. The feature vector encodes information to handle the healthy as well as the pathological retinal image. The performance of the ensemble system evaluated in detail and the incurred accuracy, robustness, and simplicity make the algorithm a suitable tool for automated retinal image analysis.

In [3] Goatman .K, Fleming .A, Philip .S, Williams .G, Olson .J, and Sharp .P proposes a new construction for Proliferative diabetic retinopathy and characterized by the development of abnormal new retinal vessels. A method for automatically detecting new vessels on the optic discussing retinal photography. Vessel-like candidate segments are first detected using watershed lines and ridge strength measurement. Fifteen feature parameters, associated with shape, position, orientation, brightness, contrast and line density are calculated for each candidate segment. Based on these features, each segment is categorized as normal or abnormal using a support vector machine (SVM) classifier. The system was trained and tested by cross- validation. It is a rare condition likely to lead to severe visual impairment.

In [4] Kochkorov .A, Gugleta .A, Zawinka .C, Katamay .R, Flammer .J, and Orgul .S presented a newly supervised method for blood vessel detection in digital retinal images. Its effectiveness and robustness with different image conditions, together with its simplicity and fast implementation, make this blood vessel segmentation proposal suitable for retinal image computer analyses such as automated screening for early diabetic retinopathy detection.

In [5] Roychowdhury .S, Koozekanani .D, and Parhi .K presented fundus images for analyzing fields of view, and generates a severity grade for diabetic retinopathy using machine learning. Classifiers such as the Gaussian Mixture model (GMM), k-nearest neighbor (kNN), support vector machine (SVM), and Ada Boost are analyzed for classifying retinopathy lesions from non lesions. GMM and kNN classifiers are found to be the best classifiers for bright and red lesion classification, respectively. A main contribution are reducing the number of features used for lesion classification by feature ranking.

In [6] Marin .D, Aquino .A, Gegundez-Arias .M, and Bravo .J presented a neural network (NN) scheme for pixel classification and computes a 7-D vector composed of gray-level and moment invariants-based features for pixel representation. Method performance on both sets of test images are better than other existing solutions in literature. The method proves especially accurate for vessel detection in stare images. Its effectiveness and robustness with different image conditions, together with its simplicity and fast implementation, make blood vessel segmentation proposal suitable for retinal image computer analyses such as automated screening for early diabetic retinopathy detection

In [7] Miri .M, and Mahloojifar .A proposes a new algorithm to detect the retinal blood vessels effectively. Due to the high ability of the curvelet transform in representing the edges, modification of curvelet transform coefficients to enhance the retinal image edges better prepares the image for the segmentation part. The directionality feature of the multi structure elements method makes it an effective tool in edge detection. Hence, morphology operators using multi structure elements are applied to the enhanced image in order to find the retinal image ridges. In order to increase the efficiency of the morphological operators by reconstruction, they were applied using multi structure elements and the image decomposed to several blocks. In order to utilize cca more efficiently and locally applied the cca and length filtering instead of considering the whole image.

The existing system is a Gaussian Mixture Model (GMM) are parametric probability density function represented as a weighted sum of Gaussian component densities. GMMs are commonly used as a parametric model of the probability distribution of continuous measure mentsor features in a biometric system, such as vocal-tract related spectral features in a speaker recognition system.GMM parameters are estimated from training data using the iterative Expectation-Maximization algorithm or Maximum A Posteriori estimation from a well-trained prior model. Algorithm for mixtures of Gaussians in that they both attempt to find the centers of natural clusters in the data. A Gaussian Mixture Model that assumes all the data points are generated from a mixture of a finite number of Gaussian distributions with unknown parameters. Mixture model should not confused with compositional data. The main difficulty in learning Gaussian mixture models from unlabeled data is that it is one usually doesn't know which points came from which latent component (if one has access to this information it gets very easy to fit a separate Gaussian distribution to each set of points). Expectation-maximization is a well-founded statistical algorithm to get around this problem by an iterative process. First one assumes random components (randomly centered on data points, learned from k-means, or even just normally distributed around the origin) and computes for each point a probability of being generated by each component of the model. Then, one tweaks the parameters to maximize the likelihood of the data given those assignments. Repeating this process is guaranteed to always converge to a local optimum.

III. IMAGE SEGMENTATION

Retinal images are influenced by all the factors that affect the body vasculature in general. The human eye is a unique region of the human body where the vascular condition can be directly observed. In addition to fovea and optic disc, the blood vessels contributes one of the main features of an retinal fundus image and several of its properties are noticeably affected by worldwide major diseases such as diabetes, hypertension, and arteriosclerosis. Further, certain eye diseases such as choroidal neovascularization and retinal artery occlusion also make changes in the retinal vasculature. It provide better edge detection and texture representation.

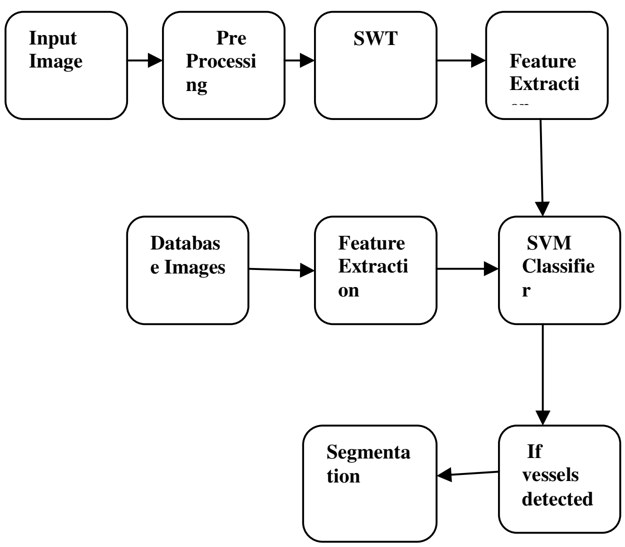

Fig. 2 System design represents Blood vessel Segmentation in fundus images . Classification and anatomical structure analysis are proposed based on Morphological Operations and K-Means Clustering.

A. Preprocessing

Preprocessing is done to extract the region of interest (ROI). Cutting or cropping out the region that contains the retinal image feature minimizes the number of operations on the retinal image. In this method, the color scale RGB images are first converted into grayscale for efficient computation. Since the exudates are visible with more contrast in grayscale an equalization procedure was performed on the images to obtain a local contrast i,e approximately, equal at all image intensities. Stationary wavelet transform (SWT) are used to extract the features from the fundus image and classification can be performed using Support Vector Machine(SVM). SVM has become an essential machine learning method for the detection and classification of particular patterns in medical images. It is used in a wide range of applications for its ability to detect patterns in experimental databases. If the vessels are present, then it is extracted by using segmentation.

B. Morphological Operation

The morphological operations are applied on the pre processed green channel. Morphological operation processes the preprocessed image with structuring element. The retinal blood vessels are detected by applying dilation and erosion process to a preprocessed image. The morphological opening and closing operation are applied to an image based on multi structure elements to enhance the vessel edges. Morphological opening and closing operation is performed by using dilation and erosion. MM was originally developed for binary images, and was later extended to grayscale functions and images. The subsequent generalization to complete lattices is widely accepted today as MM's theoretical foundation.

Fig. 3 Image Dilation And Erosion

The morphologically processed opened image and morphologically processed closed images are absolutely subtracted to detect the blood vessels from retina fundus image. The combination of dilation and erosion operations is performed on image with different structuring element of radius 3. Then, an absolute difference mapping image is formed by absolute subtraction of retinal image from the morphologically processed sub-band image. In the morphological dilation and erosion operations, the state of any given pixel in the output image is determined by applying a rule to the corresponding pixel and its neighbors in the input image. The rule used to process the pixels defines the operation as a dilation or an erosion It is a matrix containing 1's and 0's where 1's are called neighborhood pixels.

C. K-Means Clustering Method

The K-means algorithm is an iterative technique that is used to partition an image into *K* clusters. The basic algorithm are

1. Pick *K* cluster centers, either randomly or based on some heuristic
2. Assign each pixel in the image to the cluster that minimizes the distance between the pixel and the cluster center
3. Re-compute the cluster centers by averaging all of the pixels in the cluster
4. Repeat steps 2 and 3 until convergence is attained. This algorithm is guaranteed to converge, but it may not return the optimal solution. The quality of the solution depends on the initial set of clusters and the value of K

IV RESULT

For every color fundus photography, the vessel segmentation algorithm is performed in three stages and tested with following datasets that have been manually annotated for blood vessel regions. The first stage binary images are obtained in fig 4.

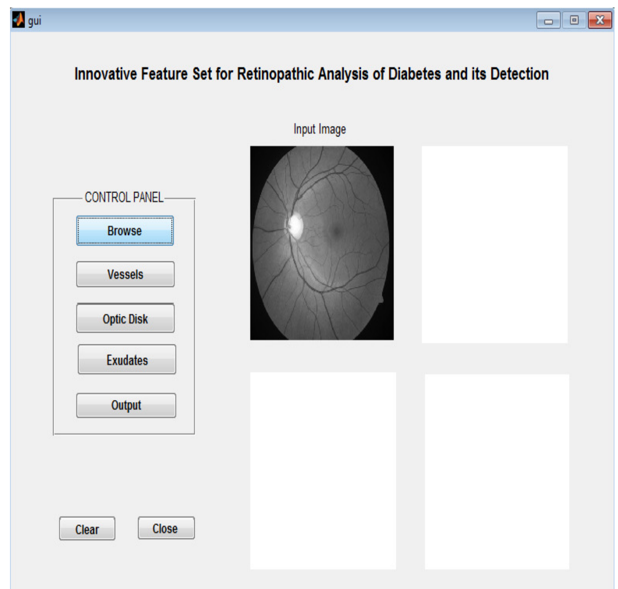

Fig. 4 Selecting The Input Image

To extract the blood vessel regions preprocessing strategies are implemented. Fig 5. which converts test image into transformed image using SVM classifier.

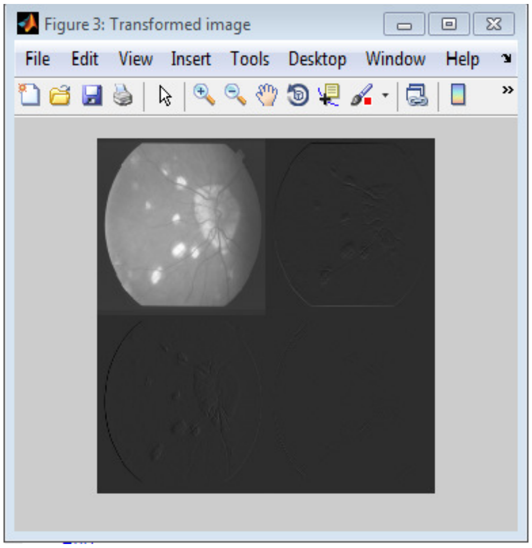

Fig. 5 Transformed Image

Support vector machine (SVM) is a widely used technique for pattern recognition and classification in a variety of applications for its ability for detecting patterns in experimental databases. Figure 6. Shows the extraction of major vessels ensures segmentation of the first category of blood vessels.

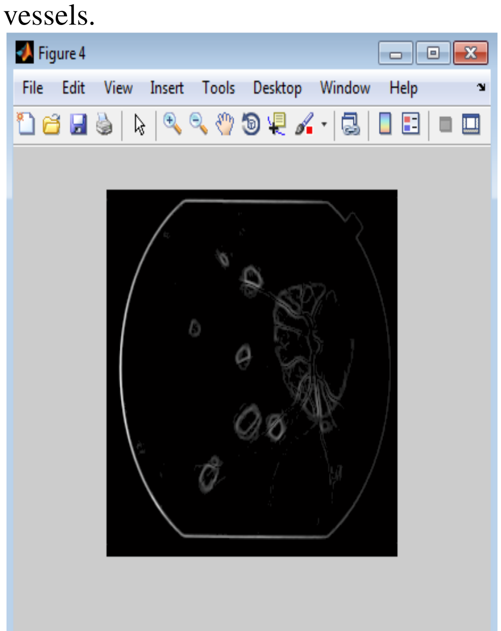

Fig. 6 Blood Vessel Detection

In order to detect and segment the retinal blood vessels accurately, the optic disc should be detected and eliminated from the retinal image. Fig 7. Shows the anisotropic diffusion filter is used to detect and segment the optic disc from the green channel retinal image.

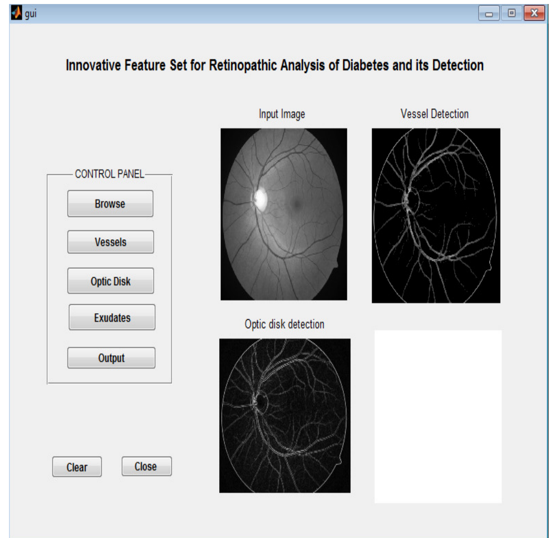

Fig 7. Optic Disk Detection

The blood vessel detection are major role in screening of eye diseases. Fig 8. Shows the detection of exudates region for diabetic retinopathy diagnosis.

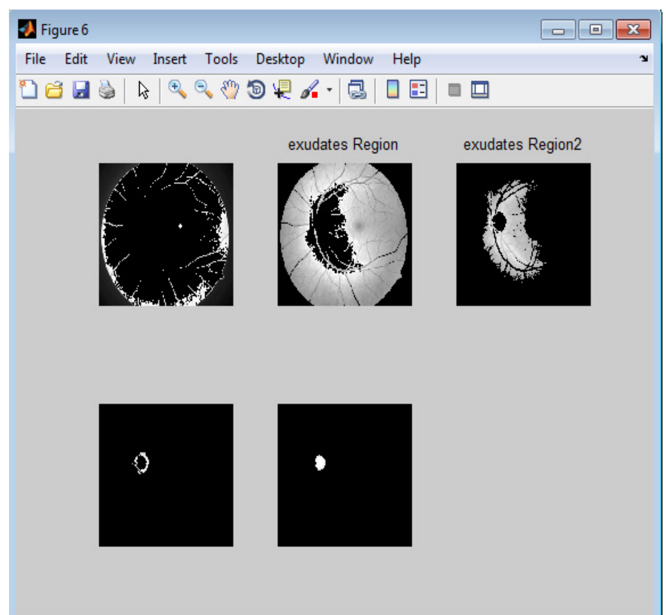

Fig 8. Exudates Region.

The result segmentation is a set of segments that collectively cover entire image, or a set of contours extracted from the image. Fig 9. Shows the Retinopathic analysis of diabetes and its detection.

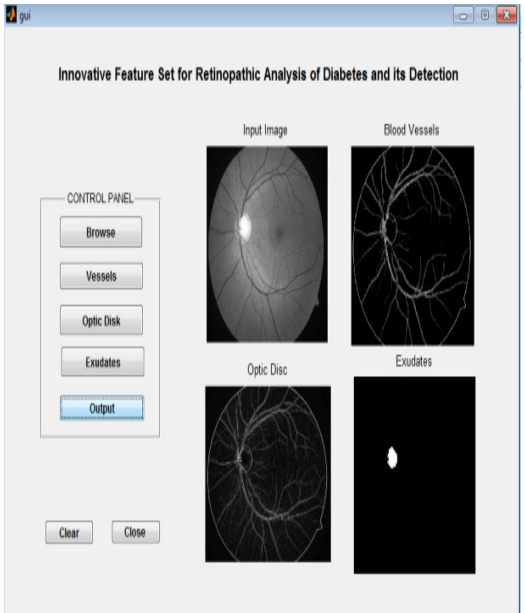

Fig 9. Segmented Output Image.

V CONCLUSION

The blood vessel detection and segmentation is an important for diabetic retinopathy diagnosis at earlier stage. Stationary wavelet transform is used to extract the features from the funds image and classification is done by using support vector machine. Support vector machine (SVM) is a widely used technique for pattern recognition and classification in a variety of applications for its ability for detecting patterns in experimental databases. SVM has become an essential machine learning method for the detection and classification of particular patterns in medical images. If the vessels are present, then it is extracted by using segmentation. The morphological operations and K-Means is proposed for detecting and segmenting the blood vessels from the retinal image. In implementation, the preprocessing steps for retinal images are analysed. It addressed two problems of preprocessing of retinal images as noise removal and background extraction. Mathematical morphology method is used for optic disc and the blood vessels detections. Optic disc detection and the blood vessels detection are the major role in the screening of eye diseases. The results of this work can be used in the future processes such as the screening of diabetic retinopathy, glaucoma and so on. The detection method doesn't need the highly efficient computer so it is suitable for rural area in developing countries.

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