RETINAL IMAGE ANALYSIS USING MORPHOLOGICAL PROCESS AND CLUSTERING TECHNIQUE

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ABSTRACT

This paper proposes a method for the Retinal image analysis through efficient detection of exudates and recognizes the retina to be normal or abnormal. The contrast image is enhanced by curvelet transform. Hence, morphology operators are applied to the enhanced image in order to find the retinal image ridges. A simple thresholding method along with opening and closing operation indicates the remained ridges belonging to vessels. The clustering method is used for effective detection of exudates of eye. Experimental result proves that the blood vessels and exudates can be effectively detected by applying this method on the retinal images. Fundus images of the retina were collected from a reputed eye clinic and 110 images were trained and tested in order to extract the exudates and blood vessels. In this system we use the Probabilistic Neural Network (PNN) for training and testing the pre-processed images. The results showed the retina is normal or abnormal thereby analyzing the retinal image efficiently. There is 98% accuracy in the detection of the exudates in the retina .

KEYWORDS

Diabetic Retinopathy, Exudates, Optic Disc, Segmentation.

1. INTRODUCTION

In an automated retinal image analysis system ,exact detection of optic disc in colour retinal images is a significant task. Detection of the same is the prerequisite for the segmentation of other normal and pathological features in the retina. The location of optic disc is used as a reference length for measuring distances in these images, especially for locating the macula. In colour fundus image shown in Figure 1, optic disc appears as a bright spot of circular or elliptical shape, interrupted by the outgoing vessels. It is seen that optic nerves and blood vessels emerge into the retina through optic disc. Therefore it is also called the blind spot. From patient to patient the size of optic disc varies, but its diameter always lies between 80 and 100 pixels in a standard fundus images. Analysis in medical images is a multi disciplinary research area, in which image processing, machine learning pattern recognition and computer visualization are covered. Ophthalmologists interprets and analyses the retinal images visually to diagnose various pathologies in the retina like Diabetic Retinopathy (DR). In order to make their work more easier

DOI : 10.5121/sipij.2013.4605

retinal image analysis system can be developed to make the diagnosis more efficiently. DR is The most common eye complication in diabetes is Diabetic Retinopathy. DR is globally the primary cause of visual impairment and causing blindness in diabetic patients. Diabetic patients have to be screened for early detection and timely treatment of diabetic eye diseases which can significantly reduce the risk of vision loss.

Reviewing vast number of images by the physicians is time consuming and costly. Several retinal abnormalities including micro aneurysms, hemorrhages, hard exudates and cotton wool spots are caused due to DR. Hard exudates are yellowish intra retinal deposits, made up of serum lipoproteins. Exudates are formed when lipid or fat leaks from abnormal blood vessels. Vision loss can occur if the exudates extend into the macular area . This paper investigates the application of Morphological approaches for detection of exudates in retinal images and compared with the normal retinal images mainly for the detection of exudates.

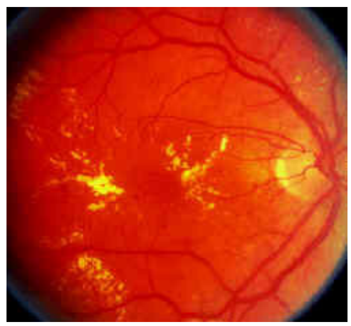

Figure 1: Digital Color Retinal Image

Here our objective is to implement an effective algorithm based on Morphological process and Segmentation Techniques to detect the Retina vessels and Exudates from an eye fundus image.

2. RELATED WORK

Kande (2008) proposes two efficient approaches for automatic detection and extraction of Exudates and Optic disc in ocular fundus images. The localization of optic disc is composed of three steps. Here, Firstly, the optic disc center is estimated by finding a point that has maximum local variance . The color morphology in Lab space is used to have homogeneous optic disc region. The boundary of the optic disc is located using geometric active contour with variational formulation. The Exudates identification involves Preprocessing, Optic disc elimination, and Segmentation of Exudates. In Exudates detection the enhanced segments were extracted based on Spatially Weighted Fuzzy c-Means clustering algorithm. This algorithm is formulated by incorporating the spatial neighborhood information into the standard Fuzzy c- Means (FCM) clustering algorithm. The Experimental results of both approaches were validated with ground truth images

Kavitha (2005) has done the automatic detection of optic disc and exudates in retinal images by following three steps: 1. Blood vessels were segmented using median filtering and morphological operations and the convergent point was detected by fitting the blood vessels data using least square polynomial curve fitting algorithm. 2. Brighter regions using multilevel thresholding were extracted that includes optic disc and exudates. 3. Optic disc (OD) was located among brighter regions from the fact that the convergent point (CP) of blood vessels falls within optic disc and other brighter regions labeled as exudates. The method was tested on normal, abnormal retinal images and the Accuracy (M), Sensitivity (S) and Predictive value (PV) were also presented. This algorithm gave promising results. Osareh, et al. (2003) proposed a system on Automatic Recognition of Exudative Maculopathy using Fuzzy C-Means Clustering and Neural Networks. Ddiabetic retinal exudates in digital colour images were identified automatically by segmenting using fuzzy C-means clustering method following some key preprocessing steps. In his system, in order to classify the segmented regions into exudates and non-exudates, an artificial neural network classifier was investigated. This system could achieve a diagnostic accuracy of 95.0% sensitivity and 88.9% specificity for the identifying the images containing any evidence of DR. Vijayakumari and Suriyanarayanan (2010) has discussed about the methods of detection of exudates in retinal images using image processing techniques. In their paper the major goal was to detect the exudates in the retina. For this, the pre-requisite is to detect optic disc, once it is found, presence of exudates could be found byusing certain algorithms. In this paper few methods were used for the detection of optic disc and exudates also the performance of all the methods were compared. Neera Singh (2010) discussed a method on automatic early detection of DR using image analysis techniques. In this paper , they have presented a method for automatic detection of optic disc followed by classification of hard exudates pixels in retinal image. Optic disc localization was achieved by iterative threshold method to identify initial set of candidate regions followed by connected component analysis to locate the actual optic disc. K- means clustering algorithm was used to determine the exudates. The algorithm was evaluated against a carefully selected database of 100 color retinal images at different stages of diabetic retinopathy. A sensitivity of 92% for the optic disc and 86% for the detection of exudates was obtained.

Ahmed Wasif Reza et al. (2009) made a system on automatic tracing of optic disc and exudates from color fundus images using fixed and variable thresholds. The proposed algorithm made use of the green component of the image and preprocessing steps such as average filtering, contrast adjustment, and thresholding. Morphological opening, extended maxima operator, minima imposition, and watershed transformation were other pre-processing steps. This algorithm was evaluated using the test images of STARE and DRIVE databases with fixed and variable thresholds. The images drawn by human expert are taken as the reference images. A sensitivity of 96.7% was achieved. Kullayamma,(2013),made a system on Retinal Image Analysis for Exudates Detection in which classification of a glaucomatous image was done using texture features within images and was effectively classified based on feature ranking and neural network. Efficient detection of exudates for retinal vasculature disorder analysis was performed. The segmented region was post processed by morphological processing technique for smoothening. Sánchez, et al.(2004), Retinal Image Analysis to Detect and Quantify Lesions Associated with Diabetic Retinopathy, An automatic method to detect hard exudates, lesion associated with diabetic retinopathy, was proposed in this paper. The algorithm determined on their color with the help of a statistical classification, and their sharp edges , an edge detector was applied to localize them. This system achieved a sensitivity of 79.62% with a mean number of 3 false positives per image in a database of 20 retinal image with variable color, brightness and quality. Vijaya Kumari et al.(2010), proposed a system on Diabetic Retinopathy-Early Detection Using Image Processing Techniques, in which an automatic method that involves two steps: optic disk detection and exudates detection. The extraction of optic disk was done using propagation through radii method. Exudates were detected using feature extraction, template matching and enhanced MDD classifiers and the methods were compared. Aravindhan, et. al.,(2010), published a paper on Automatic Exudates Detection in Diabetic Retinopathy Images Using Digital Image Processing Algorithms in which An automatic method was proposed to detect exudates from low contrast digital images of retinopathy patients. Fuzzy c-means algorithm clustered the image in to two distinct classes in the segmentation stage. Detection of bifurcation and cross-over points in fundus images in order to identify the exudates exactly was done using Advanced Modified cross point number (AMCN) methods which was employed for a window size of 7x7. This method tested 100 images and the performance was satisfactory. Thomas Walter,et. al.,(2002), made a on Contribution of Image Processing to the Diagnosis of Diabetic Retinopathy Morphological reconstruction techniques were used in order to determine the contours of exudates in Color Fundus Images of the Human Retina in which Exudates were found using their high grey level variation. Identification of optic disc was done by means of morphological filtering techniques and watershed transformation. The algorithm tested on a small image data base and compared with the performance of a human grader. A mean sensitivity of 92.8% and a mean predictive value of 92.4% was achieved.. Sunita Lokhande et.al(2013), has published a paper in Wavelet Packet Based Iris Texture Analysis For Person Authentication, this objective may be different to the identification of exudates in retina, but the method used here is in conjunction with the discrete wavelet transform in which wavelet packet transform – an extension of discrete wavelet transform is used and found that the computation complexity was less and the met the objective in an accurate way Hence by using DWT its more accurate and advantageous because the computation complexity is less and the probability of achieving accurate results is more.

3. MATERIAL AND METHODS

The digital fundus eye images were collected from an eye clinic in Chennai "Uma Eye Clinic". The database consists of 110 images in which 93 of these images contains exudates while the remaining 17 either contain other type of lesions or are normal.

3.1. Existing Method

Wavelet transform based edge detection and Segmentation like simple and global thresholding algorithm was used and there were some drawbacks in the existing methods like 1. In this method blood vessel detection process in the retinal images are difficult. 2. In Curved edges, the accuracy of edge localization in wavelet transform is small. 3. Poor Edge detection and Enhancement. In wavelet transform it cannot enhance the curved structure of the retinal images. 4. Not possible to cluster a fundus Exudates.

3.2 Proposed Method

The combination of multi structure morphological process and Segmentation technique is used effectively for retinal vessel and exudates detection here. The modules made here are 1. Retina Blood Vessels Detection in which Plane separation , Contrast Enhancement, Morphological Process are done under this module. 2. Exudates Detection in which Segmentation Technique is used.

Algorithm used for the analysis of retina:

Step 1: Input the Image
Step 2: Convert the RGB image to gray.
Step 3: Use the Bit Plane separation, Contrast Enhancement & Morphological Process to extract the retinal blood vessels.

Step 4: Applying Discrete Wavelet transform (DWT) & Energy feature coefficients for feature extraction.
Step 5: Extracted feature of the image is taken for training with Probabilistic Neural Networks(PNN).
Step 6: Classification is done with the help of segmentation like K-means Clustering method (algorithm given below) thereby extracting the exudates determining whether the retina is normal or abnormal.
Step 7: Morphological operations are applied on segmented image for smoothening the exudates part.
Step 8: Result shows that the retina is normal or abnormal.

3.2.1. System Implementation

3.2.1.1. Contrast Enhancement

To enhance and prepare the retinal image for better vessel detection a method based on curvelet transform is used here. Discrete Cosine Transform (DCT) Wrapping method which is faster and easier to implement than the Unequally Spaced Fast Fourier Transform (USFFT) method is used here. A suitable non linear function is applied to enhance image ridges by modified DCT coefficients which is one of the way to increase the image contrast . By modifying function parameters which are defined based on some statistic feature of fast DCT coefficients we can simultaneously enhance the weak edges and eliminate the noise.

3.2.1.2. Discrete Wavelet Transform(DWT)

In order to reduce dimensionality of image, DWT is used for image compression, feature extraction process. This method decomposes the image into 4 sub-bands (sub-image) ie, LL(approximation coefficients), LH(vertical details), HL(horizontal details), HH(diagonal details). The output from DWT, extracts the detailed output of input image. LL is the approximate image of input image, it is low frequency sub-band so it is used for further decomposition process. LH sub-band extracts the horizontal features of original image HL sub-band gives vertical features and HH sub-band gives diagonal features.
LH,HL,HH are high frequency sub-bands. Here follows some matlab commands which shows the useage of the sub-bands in DWT.

```
[LL,LH,HL,HH] = DWT2(X,'db5') % x is input image

figure;imshow(LL); % shows LL sub-band
```

3.2.1.3. Wavelet Energy Features

The wavelet filters decomposes the image in to the approximation and detailed energy coefficients in the Horizontal , vertical and diagonal orientation. The important texture features is determined by using the Wavelet Energy features over sub-bands. Here we use different wavelet features that is obtained from the daubechies (db3), symlets (sym3), and bi-orthogonal (bio3.3, bio3.5, and bio3.7) wavelet filters. The features average coefficient and energy are extracted and it is found by the following formula:

$$AverageDh1 = \frac{1}{p \times q} \sum_{x=(p)} \sum_{y=(q)} \left| Dh1(x, y) \right| \rightarrow (1)$$

$$AverageDv1 = \frac{1}{p \times q} \sum_{x=(p)} \sum_{y=(q)} \left| Dv1(x, y) \right| \rightarrow (2)$$

$$Energy = \frac{1}{p^2 \times q^2} \sum_{x=(p)} \sum_{y=(q)} \left| (Dv1(x, y))^2 \right| \rightarrow (3)$$

BLOCK DIAGRAM

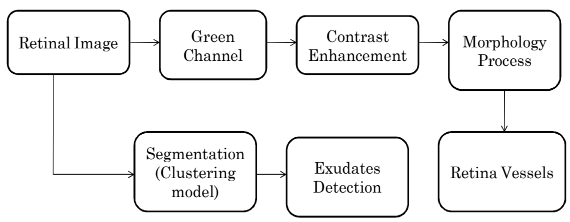

Figure 2: Block Diagram of Retinal Image analysis

3.2.1.4. A Probabilistic Neural Network (PNN)

PNN is a feed forward neural network, which was derived from the Bayesian network and a statistical algorithm called Kernel Fisher discriminant analysis. A Probabilistic Neural Network is a multilayered feed forward network with four layers:

- Input layer
- Hidden layer
- Pattern layer/Summation layer
- Output layer

3.2.1.5. Layers of PNN

PNN is often used in classification problems. The first layer is used to compute the distance from the input vector to the training input vectors when there is an input.. This produces a vector where its elements indicate how close the input is to the training input. The second layer sums the contribution for each class of inputs and produces its net output as a vector of probabilities. Finally, a complete transfer function on the output of the second layer picks the maximum of these probabilities, and produces a 1 (positive identification) for that class and a 0 (negative identification) for non-targeted classes. In this system too we apply this PNN for training the network and classification is done with the help of segmentation like K-means Clustering method (algorithm given below) hence extracting the exudates determining whether the retina is normal or abnormal.

3.2.1.6. Input layer

Each neuron in the input layer represents a predictor variable. N-1 neurons are used when there are N numbers of categories in categorical variables. The range of the values are standardized by subtracting the median and dividing by the inter-quartile range. Then the values to each of the neurons in the hidden layer are fed by the input neurons.

3.2.1.7. Pattern layer

This layer contains one neuron for each case in the training data set. The values of the predictor variables is stored in this layer for the case along with the target value.. The Euclidean distance of the test case from the neuron's center point is computed by a hidden neuron and then the Radial Basis Function kernel function using the sigma values is applied.

3.2.1.8. Summation layer

In PNN networks, there is one pattern neuron for each category of the target variable. In each hidden neuron, the actual target category of each training case is stored.; the weighted value coming out of a hidden neuron is fed only to the pattern neuron that corresponds to the hidden neuron's category. The pattern neurons add the values for the class they represent.

3.2.1.9. Output layer

The weighted votes for each target category accumulated in the pattern layer is compared by this layer and uses the largest vote to predict the target category.

3.2.1.10. Advantages

There are several advantages and disadvantages using PNN instead of multilayer perceptron

- PNNs are much faster than multilayer perceptron networks.
- PNNs can be more accurate than multilayer perceptron networks.
- PNN networks are relatively insensitive to outliers.
- PNN networks generate accurate predicted target probability scores.
- PNNs approach is Bayes optimal classification.

3.3 MORPHOLOGICAL PROCESS

Morphological operations are applied on segmented image for smoothening the image. Morphological operations processes the image based on shapes and it performs on image using structuring element. The vessel edge will be detected by applying dilation and erosion process to an image and after that by thresholding , vessels are extracted effectively. The morphological opening and closing operation are applied to an image based on multi structure elements to enhance the vessel edges and smoothening the region.

3.4 PROCESS FLOW

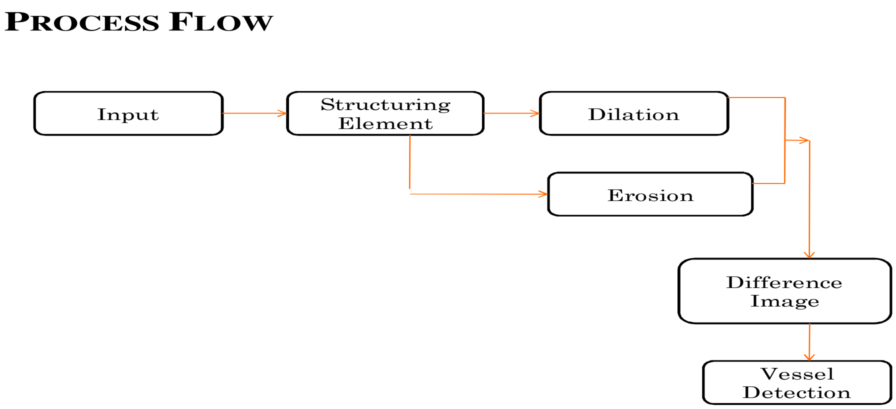

Figure 3: Flow diagram of vessel detection

3.4.1. Dilation and Erosion

These morphological operations are performed on images based on shapes. It is formed by structuring element. It is a matrix containing 1's and 0's where 1's are called neighborhood pixels. The output pixel is determined by using these processing pixel neighbors. Here, the 'disk' structuring element is used to dilate and erode the image for vessel extraction. The combination of dilation and erosion operations are performed on image with different structuring element of radius 3 and 6. Dilation: It is the process of adding a pixel at object boundary based on structuring element. The rule to find output pixel is the maximum of input pixels neighborhood matrix.

3.4.2. Erosion

It is to remove the pixel from the object boundary depends on structuring element. The rule to find output pixel is the maximum of input pixels neighborhood matrix. Morphological opening and closing operation is performed by using dilation and erosion. The opened and closed images are subtracted to extract the vessels from retina fundus image.

Finally the output image is smoothened for reducing distortion from background and edge sharpness. It is performed by using Tophat transformation based on image opening and image closing operation with multi structure elements. It will be useful to enhance the vessels from the retinal image effectively. The performance parameters are evaluated to measure the image quality.

3.4.3. Parameters for measuring the quality of the image

$$MSE = \frac{\sum_{M,N}\left[I1(m,n) - I2(m,n)^2\right]}{M \times N} \rightarrow (4)$$

MSE (Mean Square Error)

Where, M,N are Number of Rows and Columns I_1 – Original Image and I_2 – Enhanced Image.

PSNR (Peak Signal to Noise Ratio)

$$PSNR = 10\log_{10}\left[\frac{R^2}{MSE}\right] \rightarrow (5)$$

R is the maximum fluctuation in the input image data type. R is 255 here.

3.5 SEGMENTATION TECHNIQUE

The segmentation refers to the process of partitioning a digital image into multiple segments. The goal of this techniques is to simplify and change the representation of an image in to a meaningful and easy to analyse one. The segmentation is performed by using clustering algorithm. Unsupervised clustering algorithm is used here to classify the input data that points into multiple classes based on their inherent distance from each other. This method will extract the exudates from the retina fundus effectively compared to previous method.

3.6. DESIGN SPECIFICATIONS

An important technology in data mining which is an effective method of analyzing and discovering useful information from numerous data is Cluster analysis. Cluster algorithm is used to group the data into classes or clusters so that objects within a cluster have high similarity in comparison to one another, but are very dissimilar to objects in other clusters. Dissimilarities are assessed Based on the attribute values dissimilarities are assessed which describes the objects. Distance measures are often used. Being a branch of statistics and an example of unsupervised learning, from the mathematic view, clustering algorithm provides us an exact and subtle analysis tool. A popular partition method in cluster analysis is the K-means algorithm. The most widely used clustering error criterion is Squared-error criterion is the most widely used clustering error criterion which is defined as follows

$$J_C = \sum_{j=l}^{C} \sum_{k=l}^{n_j} \left\| x_k^{(j)} - m_j \right\|^2 \rightarrow (6)$$

where J, is the sum of square-error for all objects in the database, x_k is the point in space representing a given object, and m_j is the mean of cluster C_j . Adopting the squared-error criterion, K-means works well by adopting the squared-error criterion when the clusters are compact clouds that are rather well separated from one another and are not suitable for finding clusters with clusters of very different size. In order to minimize the square-error criterion, the objects in one cluster are divided into two or more clusters. In addition to that, when this square-error criterion is applied to evaluate the clustering results, the optimal cluster ranges to the extreme. The algorithm will terminate at a local optimum if the result of initialization is exactly near the local minimal point, since the objective function has many local minimal values. Hence, random selection of initial cluster center is easy to get in the local optimum and not the entire optimal. Square-error criterion is hard to distinguish the big difference among the clusters, so for overcoming this, one technique which is based on representative point-based technique has been developed. Besides, there are various approaches for solving the problem and that the performance of algorithm depends heavily on the initial starting conditions. Repetition with different random selections is the simplest one. Simulation annealing technique is also used in some cases to avoid getting into local optimal. The idea is to choose the solution having minimal distortion over all by having the multiple sub-samples which are drawn from the dataset clusters independently and then these solutions are clustered again respectively. Then the refined initial center is chosen as the solution having minimal distortion over all.

3.6.1. ALGORITHM FOR GETTING INITIAL CENTROIDS

Now let's review the standard k-means algorithm,
Input: the number of classes and the population U that
Output: k classes that satisfy the least square error.

FLOW CHART

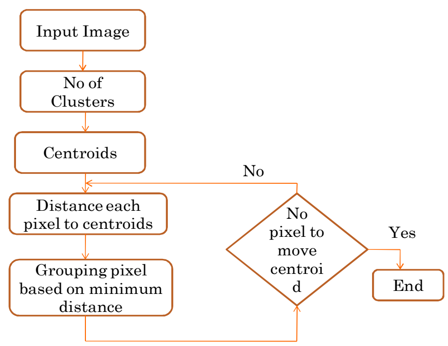

Figure 4: Flow chart determining no. of clusters and centroid

The process of the algorithm contains n objects.

(1) Select k objects randomly from the population as the initial centroids.

(2) Repeat (3) and (4) until no object changes the class t belongs to.

(3) Compute the distances between each object & and all centroids, and if one object has the shortest distance from one centroid compared to the other centroids then it has the same name as the centroid; all of these objects that have the same name belong to the same class.

(4) Average of all the vectors of objects belonging to the same class form the new centroids. The data-points reaches to their closest centroid (the E-step) which is done by the standard k-means algorithm that alternates between these data points and then moving each centroid to the mean of its assigned data-points (the M-step). A better clustering can be obtained by finding certain initial centroids that are consistent because the k-means algorithm gets easily trapped in a local minimum and different initial centroids lead to different results.

The aim of k-means algorithm is to partition objects into several classes and to make the distances between objects in the same class closer than the distances between objects in different classes. So if certain centroids in which each centroid represents a group of similar objects can be obtained, we will find out the centroids consistent with the distribution of data. Let U be a data-point set. The initial centroids can be gotten by the following steps. Firstly compute the distances between each data-point and all of the other data-points in U. Secondly, find out the two data-points between which the distance is the shortest and form a data-point set AI which contains these two data-points and we delete them from the population U. Thirdly compute distances between each data-point in AI and each data-point in U, find out the data-point that is closest to the data-point set AI (i.e. of all distances, thy distance between this data-point and certain data-point in A1 is shortest), delete it from U and add it to AI. Repeat the third step till the number of data-point in A1 reaches certain threshold. Then we go to step two and form another data-point set till we get k data-point sets. Finally the initial centroids can be obtained by averaging all the vectors in each data-point set.

3.6.2. Post Processing

Morphological operations are applied on segmented image for smoothening the exudates part. It processes the image based on shapes and it performs on image using 'line' structuring element. Dilation and erosion process will be used to enhance (smoothening) the exudates region by removing the unwanted pixels from outside region of exudates part.

FLOW CHART

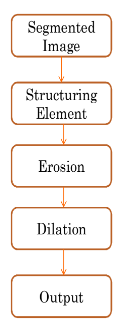

Figure 5: Flow chart for Morphological operations

3.6.3. Advantages

Better contrast enhancement, accurate retina vessel and execute detection. It is useful in Diabetic diagnosis. The Process time is faster than other clustering with more number of data points.

3.6.4. Snapshots

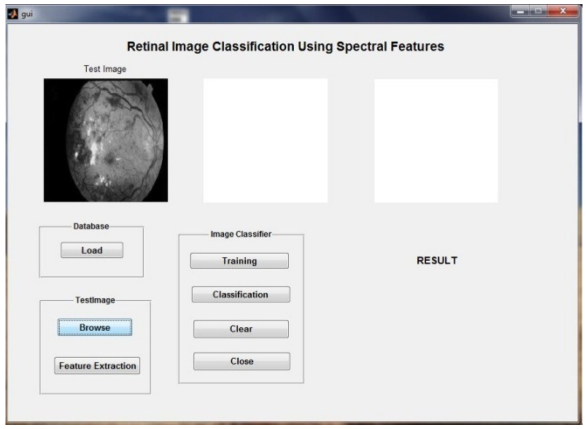

Figure: 6: GUI screen after selection of test image

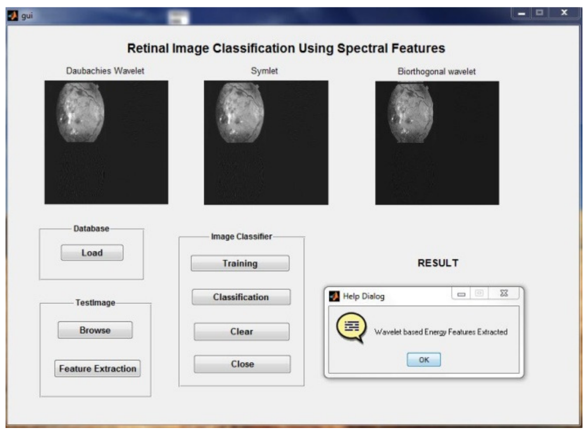

Figure.7: GUI screen after feature extraction through wavelet based energy

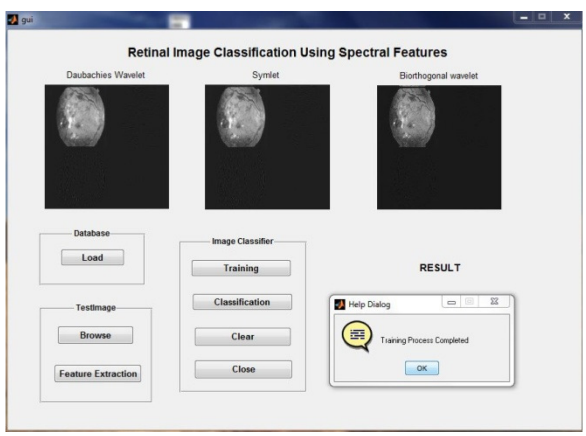

Figure.8: GUI screen after training through PNN

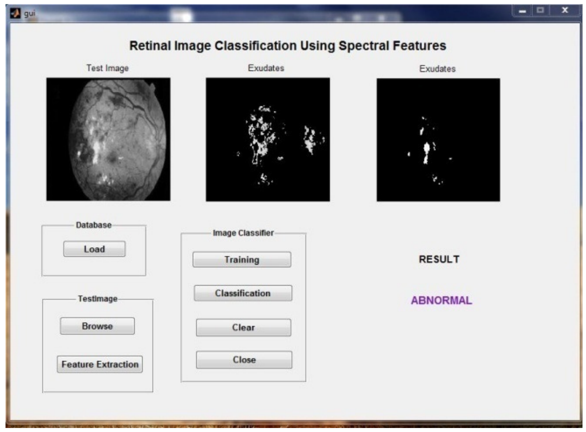

Figure.9: GUI screen after classification under unsupervised clustering method classified as abnormal

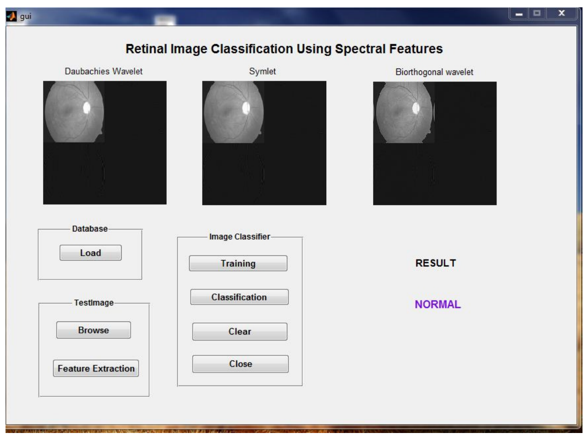

Figure.10: GUI screen for a retina showing classification as normal retina

4. RESULT AND DISCUSSION

110 images were tested and trained under the combination of multi structure morphological process and Segmentation technique which was used effectively for retinal vessel and exudates detection. Database of the images were loaded and wavelet based energy features through the Daubachies wavelet, Symlet and Bi-orthogonal wavelet were extracted successfully.

Classification was performed showing the extracted exudates and the retina is classified as either normal or abnormal depending upon the existence of the exudates in the retina. . Figure 6 shows the GUI screen after selection of test image. Figure 7 shows the feature extracted with the help of wavelet energy features and figure 8 shows that training was done with PNN network. Snapshots shown in figure 9 determines if the retina is normal or abnormal and figure 10 shows the snapshot of a normal retinal image. Figure 11 shows the extracted exudates which determine whether the retina is normal or abnormal.

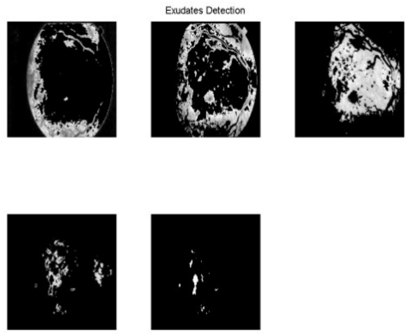

Figure 11: Extracted Exudates

5. CONCLUSION

A novel approach for the retinal vessel segmentation has been presented which shows accurate results for the database used in this system. Exact detection of the condition of a retina whether it is normal or abnormal was determined successfully. For the abnormal retina the Exudates were detected and shown accurately with the help of k-means clustering method and the feature extracted was trained with the Probabilistic Neural Network successfully. Regarding the high ability of CLAHE for retinal image contrast improvement and prepared better for segmentation step. Because of the high sensitivity of structure elements to the edges in all directions, blood vessel edges ware detected successfully by using the structure elements morphology. The false edges were removed by the morphological opening by reconstruction using multi-structure elements, same time preserved the thin vessel edges perfectly. The deficiency of missing some thin vessels is because of our utilizing a simple thresholding method. While avoiding false-edge pixel detection, the quantitative performance results of both segmentation and enhancement steps show that there is a need for a proper thresholding algorithm to find the small vessels. Also, in retinal images containing severe lesions, the algorithm needs to benefit from a higher level thresholding method or a more proper scheme. Hence, our future work is to replace the simple threshold method with a more proper approach in order to increase the accuracy of this method and deal with the problem of the presence of severe lesions in retinal fundus images.

REFERENCES

[1] Kande, G.B.,,(2008), Segmentation of Exudates and Optic Disc in Retinal Images, IEEE Transactions in Computer Vision, Graphics & Image Processing, pgs:535 – 542, Conference Publications

[2] Kavitha, D. , (2005), Automatic detection of optic disc and exudates in retinal images, IEEE , Intelligent Sensing and Information Processing, Proceedings of International Conference , Page(s): 501 – 506, Conference Publications

[3] A Osareh,1 ,M Mirmehdi,1 B Thomas,1 and R Markham2 , (2003), Automatic Recognition of Exudative Maculopathy using Fuzzy C-means Clustering and Neural Networks, Department of Computer Science, University of Bristol, Bristol, BS8 1UB, U.K., Br J Ophthalmol 2003;87, Journal in Clinical science.:pgs: 1220-1223 doi:10.1136/bjo.87.10.1220,

[4] V.Vijayakumari &, N. Suriyanarayanan, (2010), Exudates Detection Methods in Retinal Images Using Image Processing Techniques, International Journal of Scientific & Engineering Research, Volume 1, Issue 2, ISSN pgs:2229-5518, IJSER © 2010, http://www.ijser.org

[5] Neera Singh, (2010), Automated Early Detection of Diabetic Retinopathy Using Image Analysis Techniques, International Journal of Computer Applications, Volume 8– No.2, pgs: 0975 – 8887,
[6] http://en.wikipedia.org/wiki/Probabilistic_neural_network
[7] I. Kullayamma, P. Madhavee Latha, (2013), Retinal Image Analysis for Exudates Detection, International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com,Vol. 3, Issue 1, January -February 2013, pp.1871-1875.
[8] C. I. Sánchez1,2, R. Hornero1,2, M. I. López2, J. Poza1, (2004), Retinal Image Analysis to Detect and Quantify Lesions Associated with Diabetic Retinopathy, Proceedings of the 26th Annual International Conference of the IEEE EMBS, San Francisco, CA, USA • September 1-5, 2004,
[9] V.Vijaya Kumari et al. (2010), Diabetic Retinopathy-Early Detection Using Image Processing Techniques (IJCSE) International Journal on Computer Science and Engineering,Vol. 02, No. 02, 2010, 357-361.
[10] P.Aravindhan, et. al.,(2010), Automatic Exudates Detection in Diabetic Retinopathy Images Using Digital Image Processing Algorithms, Proceedings of the Int. Conf. on Information Science and Applications ICISA 20106 February 2010, Chennai, India.Panimalar Engineering.
[11] Thomas Walter, et.al. (2002), A Contribution of Image Processing to the Diagnosis of Diabetic Retinopathy—Detection of Exudates in Color Fundus Images of the Human Retina, IEEE transactions on Medical Imaging, Vol. 21. No.10, October,2002.
[12] Sunita Lokhande, et. al. (2013), Wavelet Packet Based Iris Texture Analysis For Person Authentication, Signal & Image Processing: An International Journal (SIPIJ), Vol.4, No.2, April 2013.

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