Detection and classification of exudates in retinal image using image processing techniques

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ABSTRACT

Diabetic retinopathy is a complication of diabetes that is caused by changes in blood vessels of the retina. Exudates are one of the most common diabetic retinopathy anomalies and in retinoscopy images exudates are characterized by yellowish regions with varying size and brightness. The size of these regions varies according to the stage of the patient's disease. Exudates can lead to the loss of sight when present in the macula's center region. Its detection is important because its presence is highly correlated to the presence of other Diabetic retinopathy anomalies. This could be prevented with an early screening process. Automatic computerized screening process could reduce the inspection time and increase accuracy. In this paper we have proposed algorithm for automatic exudates detection on retinal images by using Fuzzy 'C' Means (FCM) algorithm. The pre-processing stage of exudates detection including image resizing, noise removal and contrast enhancement is performed. Canny edge detector is also applied to find clear exudates. Feature extraction based on Gray Level Co-occurrence Matrix (GLCM) technique is implemented. Finally the abnormalities in retinal images and classification of retinal exudates types is developed using Fuzzy 'C' Means (FCM) algorithm and K-Nearest Neighbour (KNN) classifier.

KEY WORDS: Retinopathy, Exudates, FCM algorithm, feature extraction, KNN classifier.

1. INTRODUCTION

Diabetic Retinopathy is a complication brought on by diabetes where the retina, the light sensitive tissue that lines the inner surface of the eye is damaged. Diabetes is a disease which occurs when the pancreas does not secrete enough insulin or the body is unable to process it properly. Diabetes causes abnormal changes in the body's blood sugar levels. High levels of blood sugar can alter the blood flow to the body's organs, including the eyes. Eye damage occurs when chronically high amounts of blood sugar begin to clog or damage the blood vessels within the eye's retina. As diabetes progresses, the disease slowly affects the circulatory system including the retina and occurs as a result of long term accumulated damage to the blood vessels, the vision of a patient starts deteriorating, leading to diabetic retinopathy (Akara sopharak, 2011).

Exudates are the primary signs of diabetic retinopathy which are mainly cause of blindness and could be prevented with an early screening process (Akara Sopharak, 2009). Exudates are yellow-white lesions with relatively distinct margins. Exudates are lipids and proteins that deposits and leaks from the damaged blood vessels within the retina. It is a fluid, such as pus or clear fluid that leaks out of blood vessels into nearby tissues. The fluid is made of cells, proteins, and solid materials.It can apply to plants as well as animals. Exudates may ooze from cuts or from areas of infection or inflammation. Its composition varies but generally includes water and the dissolved solutes of the main circulatory fluid such as sap or blood. In the case of blood it will contain some or all plasma proteins, white blood cells, platelets, and in the case of local vascular damage: red blood cells. In humans, exudates can be a pus-like or clear fluid. When an injury occurs, leaving skin exposed, it leaks out of the blood vessels and into nearby tissues. The fluid is composed of serum, fibrin, and white blood cells. (Sanjeevani Choudhary and Jyotika Pruthi, 2015; Welfer.D, 2010).

Detection of exudates by ophthalmologists requires pupil dilation using a chemical solution which takes time and affects patients. Hence Automatic detection of diabetic retinopathy exudates from retinal images can provide decision support, and assist ophthalmologists to prevent and treat the disease more efficiently. In this paper we analyze and detect the exudates in retinal image which come under the diseases of retina, the category of diabetic retinopathy.

2. MATERIALS AND METHODS

We have proposed an automated system for classifying the retinal exudate type by using KNN classifier technique. The main goal of the proposed system is to automatically classify exudates diseases. The retinal images are acquired through high sensitive color fundus camera and given as input to the pre-processing. After pre-processing, the features are extracted. The abnormalities in retinal images and classification of retinal exudates types is developed using Fuzzy 'C' Means (FCM) algorithm and K-Nearest Neighbour (KNN) classifier is used to classify these retinal images does contain exudates problem or not. Block diagram of the proposed system is shown in Fig.1.

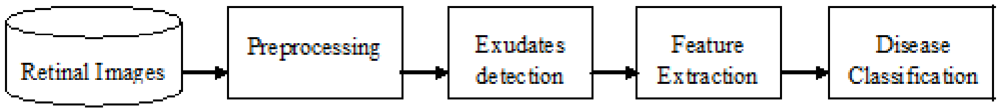


Fig.1 Block diagram of the Proposed System

Our proposed system consists of following steps

2.1. Preprocessing: Color fundus images often show important lighting variation, poor contrast and noise. In order to reduce these imperfections and generate images more suitable for extracting the pixel features in the classification process, a pre-processing comprising the following step is applied.

Various pre-processing steps:

- Image resizes to make all images a uniform size.
- Median filter is applied to remove noise from original image.
- CLAHE algorithm is applied to get enhance image.

2.2. Median Filter: The input images may contain some noises. The noise in the images is due to the uneven distribution of the intensity (I) component. These noises can be removed using filters. Here Median filter is filter used to remove noises in the images. Median filter is an effective method for suppressing isolated noise without blurring sharp edges. It replaces a pixel by the median of all pixels in the neighborhood of small sliding window. Median filter is an excellent choice for the removal of especially salt and pepper noise and horizontal scanning artifacts. As a part of image preprocessing, salt and pepper noise is added to intensity band and filtered by applying median filter of 3X3 size (Bethanney Janney, 2014).

2.3. CLAHE Enhancement: For enhancement Contrast limited Adaptive Histogram Equalization (CLAHE) algorithm is used. Contrast enhancement techniques are used widely in image processing. One of the most popular automatic procedures is histogram equalization (HE).This is less effective when the contrast characteristics vary across the image. Adaptive histogram equalization (AHE) overcomes this drawback by generating the mapping for each pixel from the histogram in a surrounding window. AHE does not allow the degree of contrast enhancement to be regulated. AHE has a tendency to over amplify noise in relatively homogeneous regions of an image. A variant of adaptive histogram equalization called contrast limited adaptive histogram equalization (CLAHE) prevents this by limiting the amplification. (Annie Grace.G.S, 2012; Raghavi.P, 2013).

2.4. Edge Detection: Edge detection is the name for a set of mathematical methods which aim at identifying points in a digital image at which the image brightness changes sharply or, more formally, has discontinuities. The image contains the edges of optic disc, blood vessels, exudates and also the image boundary. So this cannot be independently used to determine the exudates. For edge detection canny edge detector is used. The Canny edge detector is an edge detection operator that uses a multi-stage algorithm to detect a wide range of edges in images. To detect only exudates and to remove all the false detections in the previous stages, we combined the two images obtained using edge detecting method through a Boolean operation, feature based AND (VijayaKumari and Suriya Narayana, 2010).

2.5. Blood Vessel Detection: The vessels are detected as follows: If a begin point of a vessel is detected within the vessel- image, then the vessel is traced towards its end point. The begin point and the end point are marked to avoid tracing a vessel twice. The branches are detected by applying eight- connected component analysis on the branch-image (GiriBabuKande, 2009). Blood vessel detection in retinal images is a crucial fundamental step for feature extraction and interpretation of such image content (Summert Dua, 2005).

2.6. Exudates Detection: To classify the segmented region, features based on color and textures are extracted. The selected feature vectors are then classified into exudates and non- exudates using a K-Nearest Neighbour (KNN) Classifier. FCM segmentation algorithm used for enhanced image to detect the exudates in retinal image (Asha Gowda Karegowda, 2011).

2.7. Fuzzy Clustering Means: Fuzzy c-means (FCM) is a method of clustering which allows one piece of data to belong to two or more clusters. This method (developed by Dunn in 1973 and improved by Bezdek in 1981) is frequently used in pattern recognition. (Alireza Osareh., 2009).It is based on minimization of the following objective function:

$$J_m = \sum_{i=1}^{N} \sum_{j=1}^{C} u_{ij}^m \left\| x_i - c_j \right\|^2, \quad 1 \le m < \infty$$

Where m is any real number greater than 1, U_{ij} is the degree of membership of x_i in the cluster j, x_i is the ith of d-dimensional measured data, c_j is the d-dimension centre of the cluster, and ||*|| is any norm expressing the similarity between any measured data and the centre.
Fuzzy partitioning is carried out through an iterative optimization of the objective function shown above, with the update of membership U_{ij} and the cluster centre c_j by:

$$u_{ij} = \frac{1}{\sum_{k=1}^{C} \left(\frac{\left\| x_i - c_j \right\|}{\left\| x_i - c_k \right\|} \right)^{\frac{2}{m-1}}}, \qquad c_j = \frac{\sum_{i=1}^{N} u_{ij}^m \cdot x_i}{\sum_{i=1}^{N} u_{ij}^m}$$

This iteration will stop when $\max_{ij} \left\{ \left| u_{ij}^{(k+1)} - u_{ij}^{(k)} \right| \right\} < \varepsilon$, where ε is a termination criterion between 0 and 1, whereas k is the iteration steps (Shingade.A.P, 2014).

2.8. Feature Extraction: For feature calculation GLCM is used. GLCM Features (Gray Level Co-Occurrence Matrix) is a statistical method that considers the spatial relationship of pixels is the gray-level co-occurrence matrix (GLCM), also known as the gray-level spatial dependence matrix. By default, the spatial relationship is defined as the pixel of interest and the pixel to its immediate right (horizontally adjacent), but you can specify other spatial relationships between the two pixels. Each element (*I*, *J*) in the resultant GLCM is simply the sum of the number of times that the pixel with value *I* occurred in the specified spatial relationship to a pixel with value *J* in the input image.The Following GLCM features were extracted in our research work. Hurst Coefficient, Mean Average intensity, Standard Deviation-Average Contrast, Relative Smoothness, Uniformity, Entropy, Homogeneity, Contrast, Correlation, Cluster Prominence, Cluster Shade, Dissimilarity Energy (Bethanney Janney J, 2015).

2.9. KNN Classifier: Medical Image classification is one of classical problems of concern in image processing. There are various approaches for solving this problem. The aim of our proposed method is applying KNN classifier for image classification. The experimental results show the feasibility of our proposed model. KNN stands for "K-Nearest Neighbour algorithm". It is one of the simplest machine learning algorithms. An object is classified by the "distance" from its neighbours, with the object being assigned to the class which is most common among its k distance-nearest neighbours. If k = 1, the algorithm simply becomes nearest neighbour algorithm and the object is classified to the class of its nearest neighbour. We are also given a single number "k". This number decides how many neighbors (where neighbor are defined based on the distance metric) influence the classification. This is usually an odd number if the number of classes is 2. Distance is a key word in this algorithm, each object in the space is represented by position vectors in a multidimensional feature space. It is usual to use the Euclidean distance to calculate distance between two vector positions in the multidimensional space. Each of the training data consists of a set of vectors and class label associated with each vector. In the simplest case, it will be either + or – (for positive or negative classes). But KNN, can work equally well with arbitrary number of classes. The advantages of KNN classifier are analytically tractable, simple implementation, nearly optimal in the large sample limit ($N \rightarrow \infty$), lends itself very easily to parallel implementations and uses local information, which can yield highly adaptive behaviour and the disadvantages of KNN classifier are large storage requirements and computationally intensive recall. Choosing an appropriate K is essential to make the classification more successful. For performance comparison by using KNN nearest neighbour class variation, we have calculated Specificity, Sensitivity and accuracy (Sudha.L.R and Thirupura Sundari, 2014).

2.10. Performance Measure: The performance of the proposed system was evaluated using Specificity, Sensitivity and accuracy.

2.11. Specificity: Specificity measures the proportion of negatives which are correctly identified as such (e.g. the percentage of normal healthy people who are correctly identified as not having the condition, sometimes called the true negative rate. Specificity = TN/ (TN+FP).

TN – True negative and FP – False Positive

2.12. Sensitivity: Sensitivity also called the true positive rate .It measures the proportion of actual positives which are correctly identified as such (e.g. the percentage of Exudate people who are correctly identified as having the condition) Sensitivity = TP/ (TP+FN).

2.13. Accuracy: Accuracy is the proportion of true results, either true positive or true negative, in a population. It measures the degree of veracity of a diagnostic test on a condition.

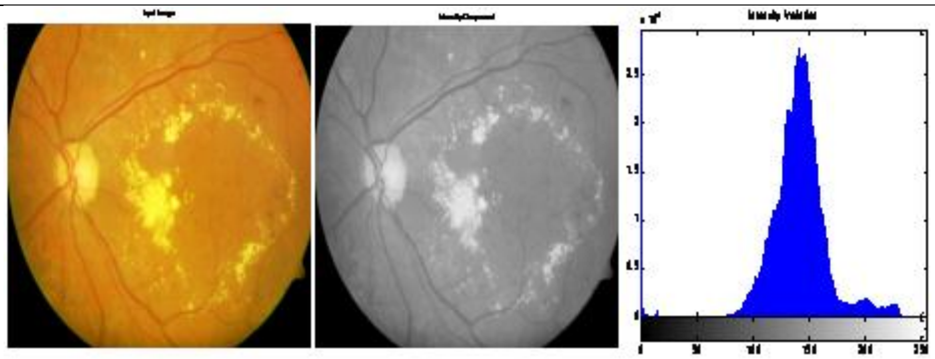
Accuracy = (TN + TP)/ (TN+TP+FN+FP).

3. RESULTS AND DISCUSSION

The input image is affected with the disease and using the FCM algorithm and KNN classifier they are detected in further process. We have trained KNN classifier by using 50 normal and 25 abnormal images. These images are classified by KNN classifier as the disease stage is moderate, mild, normal, severe or proliferative. First, we convert the original RGB image to grayscale by taking the average of the red, green, and blue channels. The Fig.2 shows the input image, the intensity component of the input image and the intensity variation of that image. The grayscale image, median filtered image and the enhanced image using CLAHE algorithm is depicted in Fig.3. From the enhanced image the edges of the image is detected. The edge of the blood vessels, exudates and each component in the retinal image is detected using canny edge detector. From the edge detected image the blood vessels are detected. To get clear information about the blood vessels eroded blood vessels is detected using the algorithm. Using the FCM segmentation the segmented areas of the input images and the exudates in the retinal images are being found out. Fig.4 showed the results of edge detected image, blood vessel detected image and the eroded blood vessel. The FCM segmented image and the exudate detected retinal image is displayed in Fig.5. Mat lab tool have been used for processing all these techniques the method followed by (Krasula, 2011).

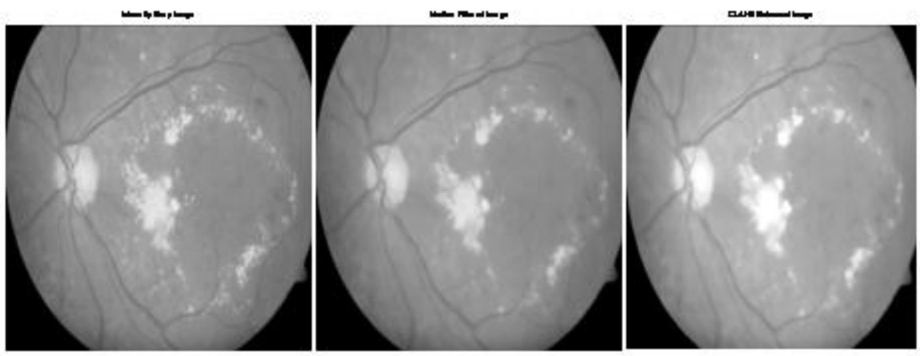
Table: 1 showed the feature extraction of samples like Hurst Coefficient, Mean Average intensity, Standard Deviation-Average Contrast, Relative Smoothness, Uniformity, Entropy, Homogeneity, Contrast, Correlation, Cluster Prominence, Cluster Shade and Dissimilarity Energy that has been extracted from real time images.

The performance of the system was evaluated. The result of the KNN nearest neighbour classification gives Accuracy of 96%, sensitivity of 90% and specificity of 94%.



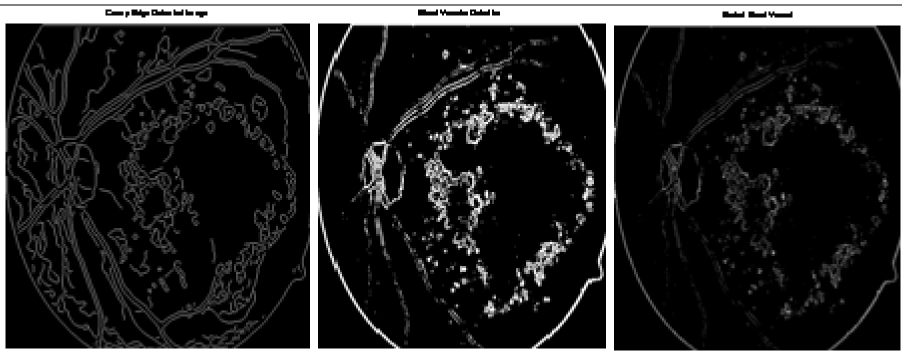
(a) (b) (c)

Fig.2 (a) Input image (b) Intensity component (c) intensity variation



(a) (b) (c)

Fig.3 (a) Intensity gray image (b) filtered image (c) CLAHE enhanced image

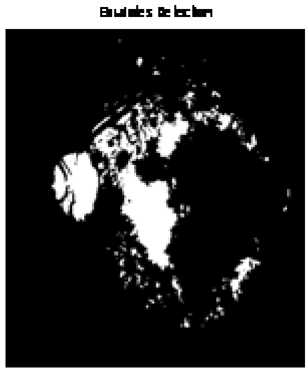


(a) (b) (c)

Fig.4 (a) Edge Detected Image (b) Blood vessel Detected Image (c) Eroded Blood vessel

(a)

Fig.5 (a) FCM Segmented Image



(b)

(b) Exudates Detected Image

Table.1.Features Extracted

S.No	Features	Image 1	Image 2	Image 3	Image 4	Image 5
1.	Hurst Coefficient	2.2204	2.4663	2.2204	2.2214	2.4663
2.	Mean Average intensity	2.2204	2.4663	2.2204	2.2214	2.4663
3.	Standard Deviation-Average Contrast	9.8699	10.032	9.8699	9.8677	10.032
4.	Relative Smoothness	2.2204	2.4663	2.2204	2.2214	2.4663
5.	Uniformity	2.2204	2.4663	2.2204	2.2214	2.4663
6.	Entropy	4.4408	4.6221	4.4408	4.4418	4.6221
7.	Cluster Prominence	1.8777	1.7564	1.8777	1.8755	1.7564
8.	Cluster Shade	-1.1542	-1.2311	-1.1542	-1.1577	-1.2311
9.	Dissimilarity Energy	2.6783	2.8544	2.6783	2.6724	2.8544

4. CONCLUSION

This paper presented an extended methodology for exudates detection in retinal images that combined pixels clustering and elimination of false candidates. We have detected the exudates and abnormalities in the retinal images by using FCM and KNN classifier. In this work we have investigated and proposed exudates detection based on segmentation techniques, we have used FCM clustering and fine segmentation using morphological reconstruction. The success of the algorithm was obtained, mostly by introduction of the detection of the exudates and classification. We also detected the type of disease based on KNN Classifier. It is also possible to show the difference between the images that is whether the disease stage is moderate, mild, normal, severe or proliferative. Blood vessel segmentation is an important pre-processing step for the early diagnosis of retinal diseases. Finally, we have concluded that Fuzzy 'C' means algorithm is better than that of Fuzzy 'K' means algorithm. This is useful when ophthalmologist visits an eye camp, he can get the retinal images of many patients using fundus camera and once these images are fed to system, the abnormalities can be easily detected. This reduces the analysis time and improves the efficiency.

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