Automated Detection Of Exudates Using FCM Clustering

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***Abstract*— Diabetic retinopathy is damage to the eye's retina that occurs with long-term diabetes. Exudates are one of the primary signs of Diabetic Retinopathy which is a main cause of blindness in patients with Diabetes. This can be prevented with an early screening process. In this paper the authors have attempted to detect hard exudates by FCM clustering algorithm. The FCM algorithm produces many clusters that human cannot make out. Optic disc is localized by the Circular Hough Transform. The publicly available diabetic retinopathy data set STARE is used for evaluation. In addition to the above set images from VASAN Eye Care Hospital (Reputed local Eye care centre) have been used. Our proposed algorithm achieved image based classification accuracy above 90%.**

***Index Terms*— Optic disc, Exudates, Diabetic Retinopathy, FCM clustering**

I. INTRODUCTION

Blindness is an outcome of diabetic retinopathy and its prevalence is set to continue rising. An estimated 50–65 new cases of blindness per 100,000 occurs every year. The screening of diabetic patients for the development of diabetic retinopathy can potentially reduce the risk of blindness in these patients by 50%. Early detection enables laser therapy to be performed to prevent or delay visual loss and may be used to encourage improvement in diabetic control. Current methods of detection and assessment of diabetic retinopathy are manual, expensive, and require trained ophthalmologists. There are different kinds of abnormal lesions caused by diabetic retinopathy, alterations in blood vessel diameter, micro aneurysms, lipid, protein deposits also known as hard exudates, cotton wool spots, hemorrhages and new vessel growth are all characteristics of Diabetic Retinopathy.

The only visible symptoms of DR in several patients are Exudates. Hard exudates occurring in the macula can cause significant visual impairment .The main obstacle in Exudates detection is extreme variability of color in retinal images that depends on the degree of pigmentation, size of the pupil and illumination. These factors affect the appearance of exudates in the retinal images. Many techniques have been employed for the exudates detection

Sinthunayothin [1] et.al used recursive region growing which yielded hard exudates as well as optic disc. Optic disc was removed by identifying the area with highest variation in intensity of adjacent pixels. Sensitivity of 88.5% and a specificity of 80.7% were obtained on a image based validation.

Akara [2] et.al used Fuzzy C-means and morphological based segmentation for diagnosing the exudates from low contrast images of non-dilated pupils Sensitivity of 80% and specificity of 99.55 were obtained. [3] Author performed a series of experiments and did a comparative analysis between mathematical morphology, fuzzy c-means clustering, Naive Bayesian classifier, Support Vector Machine, Nearest Neighbor Classifier and detected exudates were validated with ophthalmologists hand drawn ground-truths. Highest sensitivity 97.29% was obtained with FCM.Highest specificity of 99.46% was obtained with mathematical morphology.

Hussain F.Jaafar [4] et.al proposed a method based on top-down image segmentation and local thresholding by a combination of edge detection and region growing. Grading of hard exudates was performed and overall sensitivity of 93.2% was obtained.

Maria Garcia [5] .et.al used a combination of global and local thresholding for segmentation of candidate exudates regions. Group of features like mean RGB values around the region , mean RGB values inside the region standard deviation values around the region , region size were extracted from the candidate regions which are used for the training of RBF networks. The trained network performed the pixel wise classification.

R.Vijayamadheswaran[6].et.al used contextual clustering(CC) for feature extraction and extracted features were used as input to RBF network.

Neera Singh [7] et.al used fuzzy C-means clustering. Features like color, size, edge and texture are extracted from the resulting clusters. A 3 layer perceptron neural network with 18 input nodes corresponding to 18 features is used to classify pixels into exudates and non-exudates.

Nathan Silberman[8] et.al extracted SIFT features from a limited ROI region which is a horizontal conic area spanning from the location of optic disc outward toward center of the retina. These features were used to train the Gaussian Support Vector Machine to label individual patches of image.

V.Vijayakumari[9] et al used template matching for optic disc detection. Authors used sobel edge detector to find objects with sharp edges and used enhanced MDD classifier to find yellowish objects. Later images obtained from both methods are ANDed to get objects with sharp edges and yellowish color

Asha gowda[10] et.al attempted a method in which Back propagation Neural Networks are used for exudates detection. Features like Hue, Intensity, Standard deviation of intensity, distance between mean of optic disc pixels and pixels of exudates and non-exudates and mean intensity have been used as inputs to train the neural network . Decision trees and GA-CFS are used for identification of significant features. They obtained sentivity of 99.97% and specificity of 100%.

II. PROPOSED METHOD

Fig.1. shows a sample retinal image having exudates. There are three types of objects in such retinal images. Bright objects, dark objects and retinal background. Optic disc, exudates, cotton wool spots form the bright objects, blood vessels, fovea, hemorrhages form the dark objects. Retinal background is in-between the above two.

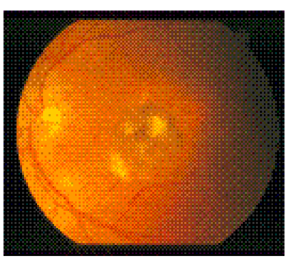


Fig.1. Retinal image having exudates

In this paper authors have attempted a novel approach for automated detection of hard exudates. The methodology is shown in Fig.2. It involves the following steps.

1. Contrast enhancement is done using CLAHE and median filter of size 3X3 is used to remove noise.
2. Hough transform is used for the detection of the optic disc
3. FCM clustering algorithm for the detection of exudates.

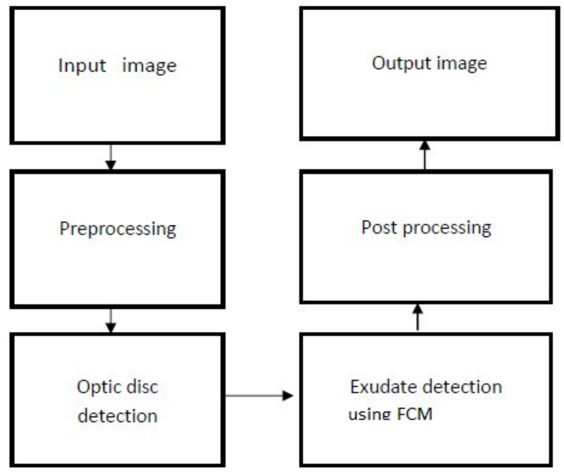


Fig 2: Proposed system of exudates detection

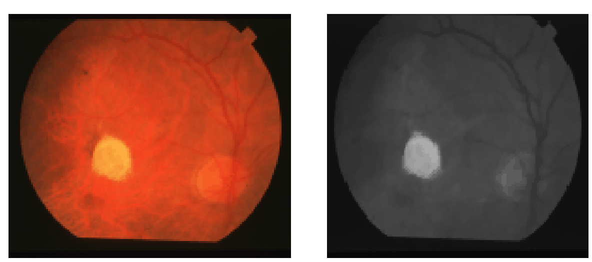
Image acquisition

Twenty five images from Standard Diabetic Retinopathy dataset STARE [13] are used for training and evaluation of the proposed algorithm. Twenty five images from the local hospital VASAN EYE CARE are also used for training and testing.

Image Pre-processing:

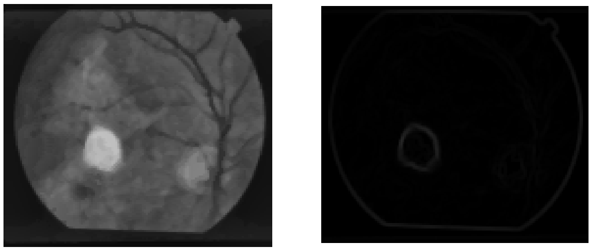
The input images are in RGB format. The images are indexed images of size 150*130. The images are retained in RGB space. We examined the red green and green planes and exudates are more clearly visible in the green plane. The green plane was median filtered using a median filter of size 3*3. Median filter has the advantage of removing the noise at the same time edge preserving property. The image is enhanced using CLAHE contrast limited adaptive histogram equalization.

Noise removal: The image was filtered using median filter of size 3X3 which removes the noise effectively while preserving edges.



(a) (b)

Fig.3 a) Original Retinal image b) Median filtered green plane



(c) (d)

Fig.3.c) Contrast enhanced image d) Standard deviation of green plane

Optic Disc Detection:

The Optic Disc (OD) is the brightest part in normal fundus retinal images. It is the entrance region of blood vessels and optic nerves to the retina and it works as landmark to other features in the retinal fundus image. Locating and segmenting OD is an important prerequisite in automatic detection of exudates since it has characteristics similar to exudates in terms of color, shape, brightness and contrast. It has been detected using edge detection followed by circular Hough transform. The result of optic disc detection by Hough transform is shown in fig.4.Optic disc thus obtained is superimposed on the result obtained by FCM algorithm.

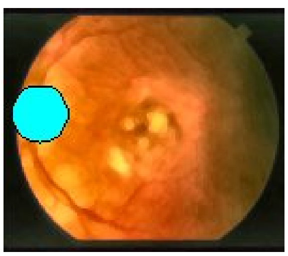


Fig.4. Optic disc detection by Hough transform

Detection of Exudates using FCM Clustering:

I. FCM Clustering:

In this study we apply Fuzzy C Means clustering technique. In fuzzy clustering, each point has a degree of belonging to clusters, as in fuzzy logic, rather than belonging completely to just one cluster. Thus, points on the edge of a cluster, may be in the cluster to a lesser degree than points in the center of cluster. Any point x has a set of coefficients giving the degree of being in the kth cluster $w_k(x)$. With fuzzy c-means, the centroid of a cluster is the mean of all points, weighted by their degree of belonging to the cluster:

$$c_k = \frac{\sum_x w_k(x)x}{\sum_x w_k(x)}.$$

The degree of belonging, $w_k(x)$, is related inversely to the distance from x to the cluster center as calculated on the previous pass. It also depends on a parameter m that controls how much weight is given to the closest center. The following steps are followed in FCM.

- Choose a number of clusters.
- Assign randomly to each point coefficients for being in the clusters.
- Repeat until the algorithm has converged (that is, the coefficients' change between two iterations is no more than ε, the given sensitivity threshold) :
- Compute the centroid for each cluster, using the formula above.
- For each point, compute its coefficients of being in the clusters, using the formula above.

The objective function is given by

$$J = \sum_{i=1}^{M} \sum_{j=1}^{C} u_{ij}^2 ||x_i - c_j||^2, \qquad (1)$$

$$u_{ij} = [\sum_{k=1}^{c} (||x_i - c_j|| / ||x_i - c_k||)^2]^{-1}, \qquad (2)$$

$$c_j = \frac{\sum_{i=1}^{M} u_{ij}^2 x_i}{\sum_{i=1}^{M} u_{ij}^2} \qquad (3)$$

where M is the number of features ,C is the number of clusters, u_{ij} is the degree of membership of x_i in the cluster j, x_i is the ith item of the d-dimensional measured data, c_j is the centre of the cluster, and ||*|| is any norm expressing the similarity between any measured feature and the centre.

Pseudocode

Step 1 : Initialise the fuzzy partition matrix $U=[u_{ij}]$ $(U^{(0)})$ by generating random numbers in the range 0 to 1 subject to

$$\sum_{i=1}^{M} \sum_{j=1}^{C} uij = 1$$

Step 2: Calculate the center vectors $C^{(k)} = [c_j]$ with U^k according to (3).

Step 3 : Obtain $U^{(k+1)}$ by using the newly computed u_{ij} according to (2).

Step 4 : Compute Jaccording to (1). If (4) is satisfied, stop. Otherwise, return to step 2.

II. Feature selection for FCM:

We have chosen three parameters for FCM .

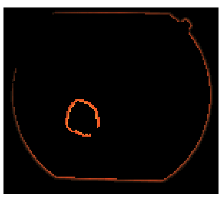
1. Green plane
2. Standard deviation of an image,
3. Contrast enhanced image.

The initial number of clusters was given as 7.

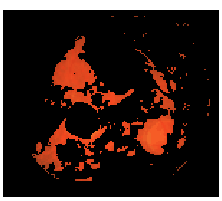
The FCM algorithm has produced seven clusters. The different clusters are shown in Fig 5 1-7. As the image shows cluster 1 contains the exudates.

objects in cluster 1

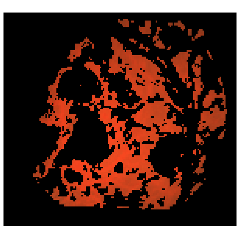
objects in cluster 2



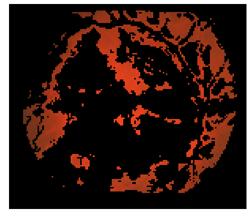
objects in cluster 3



objects in cluster 4



objects in cluster 5



objects in cluster 6

objects in cluster 7

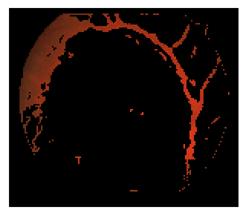
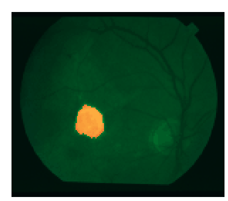


Fig 5. 1-7 Clusters produced by FCM clusters

The 1st cluster is thresholded to get a binary image. Fig 6 shows the result of segmentation overlaid on original image.

Fig.6 a)Result of Thresholding 1st cluster



b) Result of segmentation overlaid on original image

III. Experimental results

Fig 7 shows the original retinal images and the regions classified as exudates after segmentation. We have tested on 20 images on the STARE database in which optic disc is nearly circular for our study. On an image based validation criterion we have obtained an accuracy of above 90%. The results obtained from FCM algorithm. FCM is able to detect exudates in all images

Original retinal image   Result after segmentation

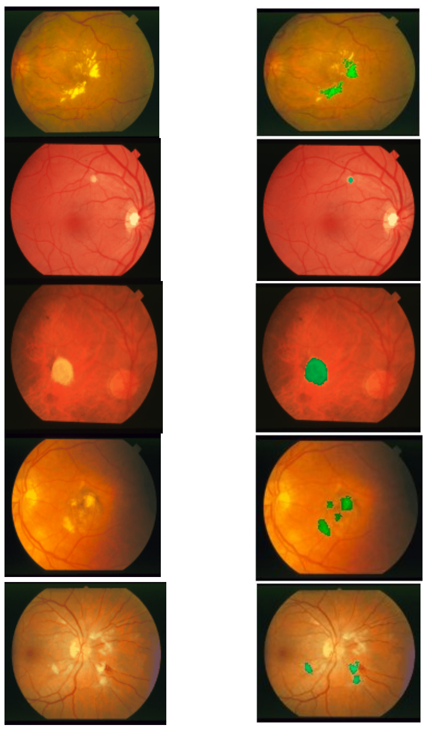


Fig.7.a.Retinal image   b. Regions classified as exudates

Fig 8 shows the results of FCM on different images

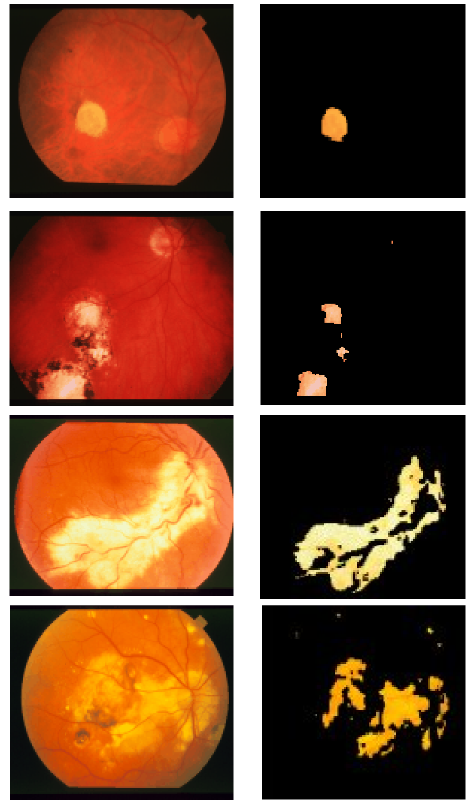


Fig 8 1-4 Result of FCM on different images

IV. Conclusion

The use of clustering algorithm reduces the amount of training data as well as time. There are some non-Ex regions that are classified as Ex. The quality of retinal images plays a vital role .In our future work we will try to improve lesion based accuracy. This system can be used as a preliminary diagnosis tool to help the ophthalmologists in the initial screening process. Development of a screening system, which provides a simple yes-no answer, may be enough to reduce diabetic screening requirement by a trained personnel by up to 70%.

V. ACKNOWLEDGMENTS

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