

An Effective Segmentation of Diabetic Retinopathy Image Using Penalized FCM

Neeraja B K¹, D. Anto Sahaya Dhas²

Department of ECE,

Vimal Jyothi Engineering College, Kannur, Kerala

Corresponding Authors: *neeraja.balan@gmail.com¹, dr.anto@vjec.ac.in²*

Abstract

Diabetes is a group of metabolic diseases in which there are high blood sugar levels over a prolonged period. Diabetic retinopathy (DR) is a complication of diabetes, causing abnormalities in the retina. It can eventually lead to blindness. The longer a person has diabetes higher their risk of developing some retinal problem. So it is necessary for a diabetic patient to have regular checkups. An automatic detection system using image processing techniques for DR will help to save the cost and time. Early detection of the problem will help the patients from vision loss. In this paper, an effective method for the segmentation DR image using Penalized FCM is proposed. PFCM is a modified version of FCM.

Keywords: *Diabetic Retinopathy Image, Penalized FCM, Diabetes*

INTRODUCTION

Diabetes is one of the rapidly increasing threats worldwide. Diabetes may cause abnormalities in kidney, retina and nervous system. Diabetic retinopathy also known as diabetic eye disease is when damage occurs to the retina due to diabetes. It can eventually lead to blindness. After 20 years

of diabetes, nearly all patients with diabetes will have some degree of retinopathy. The first detectable change is the presence of Micro aneurysms followed by hard and soft exudates.

Image processing techniques can be applied to retinal or fundus image for the detection

of diabetic retinopathy. It includes preprocessing, segmentation, feature extraction, feature selection and classification stages.

C. Sinthanayothin proposed a recursive region growing segmentation algorithm which is the identification of similar pixels within a region to determine the location of a boundary. To establish if two adjacent pixels are similar they must satisfy some criterion such as grey level or colour. In RRGs, adjacent pixels within the same region are considered to have fairly homogeneous grey scale properties^[1].

Tatiraju *et. al* proposed K means clustering to detect exudates and non exudates as a result of the number of clusters formed. Exudates are located in high intensity range whereas the other lesions are present in the low intensity range. Maximum and minimum intensity values are calculated and serve as a distance measure. The process is repeated and the cluster centers are updated in each step^[2].

Akara Sopharak *et. al* put forward the result of an automated detection of exudates from low contrast digital images of retinopathy patients with non-dilated pupils by Fuzzy C Means clustering. Four features such as

intensity, standard deviation on intensity, hue and a number of edge pixels were extracted and applied as input to coarse segmentation using FCM clustering method^[3].

An automatic and efficient method to detect Optic Disk and exudates was proposed by G.S. Annie Grace Vimala *et. al*. The retinal images are pre-processed using the technique of LAB color space image. The low contrast digital image is enhanced using Contrast Limited Adaptive Histogram Equalization (CLAHE). The preprocessed color retinal images are segmented using Line operator and Fuzzy C Means Clustering technique in order to detect Optic Disk. The exudates are extracted using Kmeans clustering. To Classify these segmented image into exudates and non-Exudates, a set of features based on texture and color are extracted using Gray Level Co occurrence Matrix (GLCM). Then the selected features are classified into exudates and non-exudates using Support Vector Machine (SVM) Classifiers^[4].

Clustering methods are one of the widely used algorithms in image segmentation. These are methods that attempt to group together patterns. Clustering algorithms assume that pixels belonging to the same

cluster have a similar behavior, which may be uniform features like grey levels, texture or colour.

SEGMENTATION USING PENALIZED FUZZY C MEANS

Retinal color images captured using different devices have variations in intensity and illumination. Noise may also present in these images due to patient movement or bad positioning of the device. All these affect the quality of the retinal image. So it is necessary to perform preprocessing techniques including filters.

For the preprocessing of the retinal image ORNRAD (Oriented Rician Noise Reduction Anisotropic Diffusion) filter is adopted which is found to have maximum PSNR and minimum MSE. ORNRAD is based on Linear Minimum Mean Square Error (LMMSE) and Speckle Reducing Anisotropic Diffusion (SRAD) for Rician distributed noise. LMMSE estimator achieves minimum MSE among all the estimators and SRAD is edge sensitive diffusion which preserves the edges of the blood vessels in the retina. This scheme does not depend on the norm of gradient for the filtering that normally varies in image. It

also converges without smoothing out interesting feature of the image^[5].

Segmentation is to simplify and change the representation of an image into another image that is more meaningful and easier to analyze. Segmentation is done in retinal images to group regions with similar properties or characteristics. It partitions the image into its constituent connected regions. There are many segmentation techniques and these image segmentation approaches can be divided into four categories: thresholding, clustering, edge detection and region extraction. Clustering is a process for classifying objects in such a way that objects of the same group are more similar to one another than objects belonging to different groups. Fuzzy clustering methods are a type of clustering method, in which Fuzzy c means is the most popular method. The popularity of FCM is due to its robustness. Here segmentation is done using Penalized Fuzzy C Means algorithm.

Fuzzy C-Mean (FCM) is an unsupervised clustering algorithm. Using fuzzy algorithm, each pattern can be associated with every cluster using a membership function. The assumption made in this technique is the prior knowledge of the number of clusters.

The membership function gives the probability that a pixel belongs to a specific cluster. In this algorithm, the probability is based solely on the distance between the individual cluster center and the pixel in the feature domain. When the location of a new cluster center is updated, the degree of membership depicts how much each pattern contributes in adjusting the new cluster center location FCM is an iterative process and produces an optimal c partition. This is achieved by minimizing the weighted within group sum of squared error objective function. This clustering process is related only to grey levels independently of pixels of the image in segmentation. This shows that conventional FCM does not take into account any spatial dependence. This also makes it more noise sensitive.

Penalized Fuzzy C-Mean (PFCM) is modified FCM algorithm. In PFCM, a penalty term considers the spatial dependence of the object which is inspired by the Neighbourhood Expectation maximization algorithm and is modified according to the FCM criterion^[6]. The objective function of the PFCM is given by

$$J_{PFCM} = \sum_{k=1}^n \sum_{i=1}^c (u_{ik})^q d^2(x_k, v_i) + \gamma \sum_{k=1}^n \sum_{j=1}^n \sum_{i=1}^c (u_{ik})^q (1 - u_{ij})^q w_{kj}$$

Where

$$w_{kj} = \begin{cases} 1 & \text{if } x_j \text{ and } x_k \text{ are neighbors and } j \neq k \\ 0 & \text{otherwise} \end{cases}$$

$\gamma (\geq 0)$ controls the effect of penalty term

When $\gamma = 0$, objective function of PFCM becomes equal to objective function of FCM.

In order to add the spatial dependence of the objects a modified version of conventional expectation maximisation algorithm is used. The modified version is Neighbourhood Expectation Maximisation. The difference between NEM algorithm and PFCM algorithm is that the penalty term should be maximized and minimized respectively. The penalty term in the PFCM algorithm has the weighting exponent q to control the degree of fuzziness. When the PFCM algorithm converges, a defuzzification process takes place to convert the fuzzy partition matrix into a crisp partition which is the segmented image. The advantage of this algorithm is that it can handle small and large amounts of noise by adjusting a penalty coefficient.

RESULTS AND DISCUSSION

The diabetic retinopathy images were taken from publicly available DIARETDB1 database. The input image is 2D colour retinal image. The ORNRAD filter for preprocessing was implemented in MATLAB. It was tested for various images and the corresponding PSNR and MSE were found. MSE of a filter is one of the ways to evaluate the difference between true value and the value implied by a filter. PSNR is a ratio between the maximum possible value and the value of corrupting noise of a signal that has influence on the quality of its representation. A filter with minimum MSE and maximum PSNR is said to be a good filter.



Fig. 1 Input image

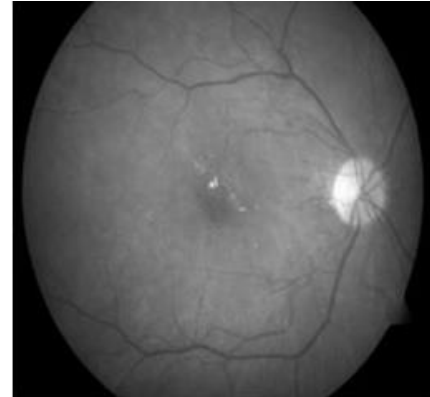


Fig. 2 Gray scale image

MSE is found using the equation

$$MSE = \frac{1}{A \times B} \sum_{i=1}^n \sum_{j=1}^n (n_{i,j} - m_{i,j})^2$$

Image size given as input is in size A x B, where $n_{i,j}$, $m_{i,j}$ are the initial image and the reconstructed image respectively.

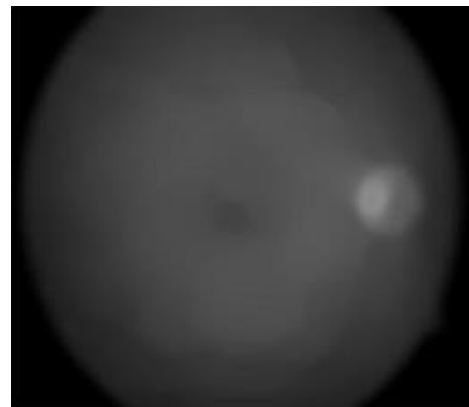


Fig. 3 Preprocessed output

PSNR is found using the equation

$$PSNR = 20 \cdot \log_{10} \left(\frac{MAX_{IM}}{\sqrt{MSE}} \right)$$

Table 1 shows the PSNR and MSE obtained for various retinal images that were taken from DIARETDB1 database.

Table 1 PSNR and MSE for various retinal images

PARAMETER IMAGE	PSNR	MSE
IMAGE 1	37.9469	0.0545
IMAGE 2	38.5860	0.0445
IMAGE 3	37.4859	0.0497
IMAGE 4	39.3773	0.0390
IMAGE 5	32.5293	0.1088
IMAGE 6	33.6186	0.1088
IMAGE 7	37.4955	0.0250
IMAGE 8	34.9225	0.0771
IMAGE 9	37.9821	0.0338
IMAGE 10	35.3296	0.0608

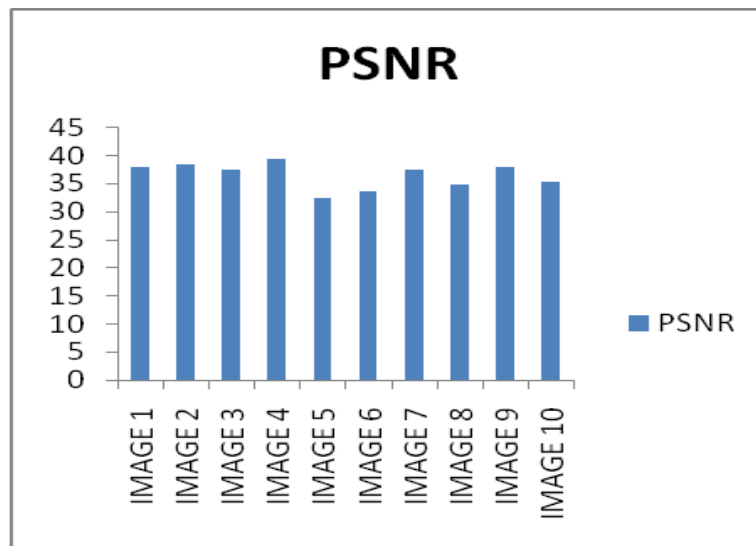


Fig. 4 PSNR for various retinal images

The average PSNR obtained is 36.5273.

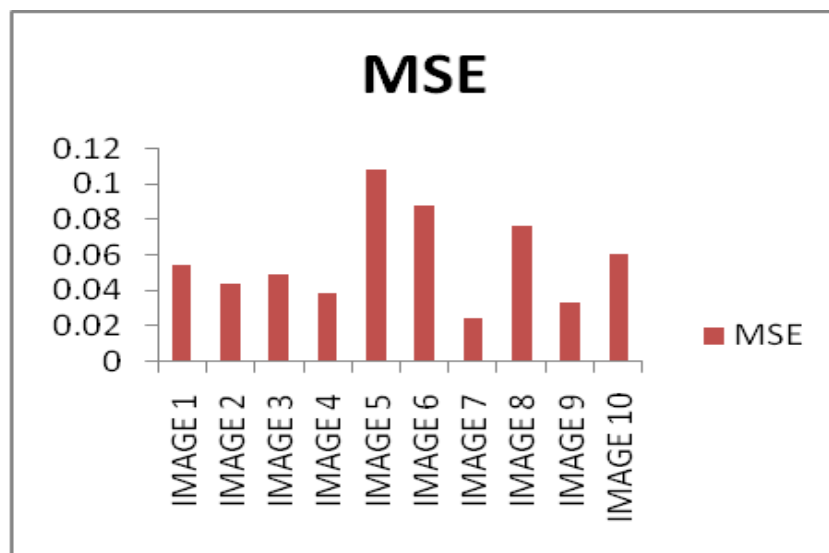


Fig. 5 MSE for various retinal images

Average MSE obtained is 0.05814.

The preprocessed image is then segmented using FCM and PFCM. Result of both FCM and PFCM segmentation is given below.

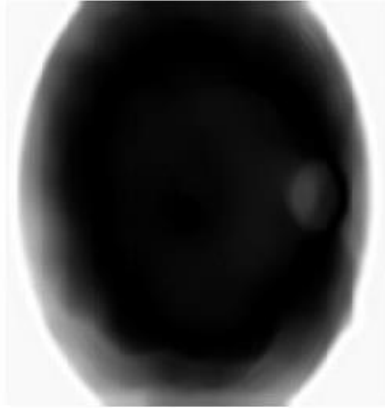


Fig. 4 FCM segmented image

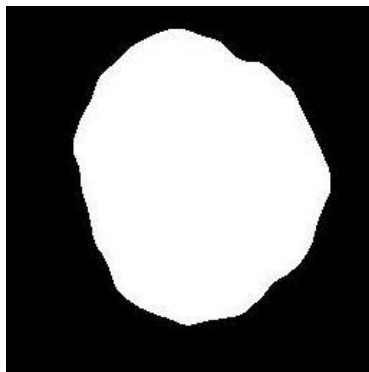


Fig. 5 PFCM segmented image

CONCLUSION

Diabetic retinopathy eye diseases are one of the cause of vision loss and this is going to continue rising in the present scenario. Currently methods for early detection of

diabetic retinopathy are less in number. An automatic CAD system for the early detection of DR will be very helpful to the ophthalmologists and it will help to save the people from vision loss. Preprocessing of the retinal images were done using ORNRAD filter in MATLAB and identified that it has maximum PSNR and minimum MSE. This is very essential for the further analysis of the retinal image. Penalized Fuzzy c means clustering algorithm was selected as the method for the segmentation. This method is found to be modified FCM and reduces the noise sensitiveness of FCM.

REFERENCES

- 1) Sinthanayothin, C., Boyce, J. F., Williamson, T. H., Cook, H. L., Mensah, E., Lal, S. and Usher, D., Automated detection of diabetic retinopathy on digital fundus images. *Diabetic Medicine*, 2002, 19, 105–112.
- 2) Tatiraju, Suman, and Avi Mehta, Image Segmentation using kmeans clustering, EM and Normalized Cuts. Department of EECS, University Of California–Irvine, 2008, pp. 1-7.

- 3) Akara Sopharak, Bunyarit Uyyanonvara and Sarah Barman, Automatic Exudate Detection from Non-dilated Diabetic Retinopathy Retinal Images Using Fuzzy C-means Clustering. *Sensors*, 2009, 9, 3, pp. 2148–2161.
- 4) Annie Grace Vimala, G.S., Kaja Mohideen, S., Automatic Detection of Optic Disk and Exudate from Retinal Images Using Clustering Algorithm, *Proceedings of 7th International Conference on Intelligent Systems and Control (ISCO 2013)*, 2013.
- 5) Vijikala, V., Anto Sahaya Dhas, D., Identification of most Preferential Denoising Method for Mammogram images, *IEEE Conference proceedings*, 2015, DOI:10.1109/ICE DSS.2016.758786.
- 6) Yong Yang, Shuying Huang, Image Segmentation By Fuzzy C-Means Clustering Algorithm With A Novel Penalty Term, *Computing and Informatics*, 2007, 26, 17–31.
- 7) Shahira M. Habashy , Identification of Diabetic Retinopathy Stages using Fuzzy C-means Classifier , *International Journal of Computer Applications* , 2013, 77, 9, (0975 – 8887).
- 8) Aibinu, A.M., Iqbal, M.I., Nilsson, M., Salami, M.J.E., Automatic Diagnosis of Diabetic Retinopathy from Fundus Images Using Digital Signal and Image Processing Techniques, *Proceedings of the International Conference on Robotics, Vision, Information and Signal Processing* , 2007, 15, 2, 47-52.
- 9) Budai, A., Bock, R., Maier, A., Hornegger, J., and Michelson, G., Robust Vessel Segmentation in Fundus Images, *International Journal of Biomedical Imaging*, 2013, Article ID 154860, 11.
- 10) Carson, C., Belongie, S., Greenspan, H., and Malik, J., Blobworld: Image segmentation using expectation-maximization and its application to image querying. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 2002, 24, 8, pp. 1026–

1038. Microaneurysms in Retina Photographs. IEEE transactions on medical imaging, 2008,27, 9,1230-1240.
- 11) JayaKumari, C., Maruthi, R., Detection of Hard Exudates in Color Fundus Images of the Human Retina. Procedia Engineering, 2012,30, 297 – 302.
- 12) Ravivarma, P., Ramasubramanian, B., Arunmani, G., Babumohan, B., An Efficient System for the Detection of Exudates in Colour Fundus Images using Image Processing technique. IEEE International Conference on Advanced Communication Control and Computing Technologies (ICACCCT), 2014.
- 13) Tomasi, C. and Manduchi, R., Bilateral filtering for gray and color images. Proceedings of the 6th IEEE International Conference on Computer Vision (ICCV '98) , 1998,839–846.
- 14) Gwenole Quéllec, Mathieu Lamard, Pierre Marie Josselin, Guy Cazuguel, Beatrice Cochener, and Christian Roux , Optimal Wavelet Transform for the Detection of
- 15) Jaspreet Kaur, Dr. Sinha, H. P., Automated Detection of Diabetic Retinopathy Using Fundus Image Analysis . International Journal of Computer Science and Information Technologies, 2012, 3 ,4 ,4794 - 4799.