

RETINAL IMAGE CLASSIFICATION AS NORMAL AND ABNORMAL USING SUPPORT VECTOR MACHINE

Kumudham R

ECE Department, Vels University
Pallavaram, Chennai, Tamil Nadu, India

ABSTRACT

Diabetic Macular Edema (DME) is a common retinal complication associated with diabetes. It is a major cause of permanent vision loss. Therefore early detection will be highly beneficial in controlling the progress of the disease. Since the ratio of people affected with the disease is very high when compared to the number of eye specialist, there is a need for automated diagnostic system for DME, so that only diseased persons can be referred to the specialist for further intervention and treatment. In order to assess DME, Detection of Hard Exudates is now considered as a standard method. In this paper the Hard Exudates are segmented using Fuzzy Clustering algorithm. Local Binary Pattern features are extracted from the segmented regions and are input to the Support Vector Machine (SVM) Classifier. The SVM classifier classifies the image as Normal and Abnormal.

Keywords— Diabetic Macular Edema, Vision Loss, Diabetic Retinopathy, Retinal Complication, Hard Exudate, Fuzzy Clustering, Support Vector Machine.

1. INTRODUCTION

Diabetic Macular Edema is caused by complications of diabetes, which can ultimately lead to permanent vision loss. It is an ocular manifestation which affects up to 80% of all patients who have diabetes for 10 years or more. Wisconsin Epidemiologic Study of diabetic retinopathy reported the 14-year incidence of DME in type I diabetics to be 26%. Despite these intimidating statistics, research indicates that at least 90% of these new cases could be minimised if there was proper and vigilant treatment and checking of the eyes. The longer a person has diabetes, the higher is the chance of developing Diabetic Macular Edema.

Diabetic Macular Edema (DME) is an advanced symptom of diabetic retinopathy. Macular edema occurs when fluid and protein accumulate in the macula of the eye. This causes thickening and swelling. The swelling may deteriorate a person's central vision, as the macula is near the centre of the retina at the back of the eyeball. This area has tightly packed cones which provide clear central vision to enable a person to see. Until recently there was no good treatment for macular edema caused by central retinal vein occlusion (CRVO).

The screening of diabetic patients, who have the chance of developing diabetic macular edema, can potentially moderate the risk of blindness in these patients. Early screening 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 assessment of diabetic macular edema are expensive and require trained eye specialists. Hard Exudates are one of the primary signs of Diabetic Macular Edema. Automatic exudates detection would be helpful for Diabetic Macular Edema screening process.

Screening programmes are launched in many countries and colour fundus images are used by medical experts for manual assessment. Such manual assessment is not suitable in large scale scenario. In such a scenario automated system reduce the load of experts by limiting the referrals to those cases that require immediate attention. The ratio of normal patients to the ones showing disease symptoms is high in Diabetic Macular Edema screening. Several attempts have been reported towards building an automated solution for Diabetic Macular Edema detection. This has motivated us in developing a solution for automatic assessment of Diabetic Macular Edema from colour fundus images. Such a solution will add value to the existing infrastructure of Diabetic Macular Edema screening.

2. RELATED WORK

Akara et al. [1] have given a set of morphological operators adjusted optimally to be utilized for exudates detection on diabetic retinopathy patients' non-dilated pupil and low-contrast images. Those automatically detected exudates were evaluated by comparing with ophthalmologists hand-drawn ground-truths. The experimental results showed that the sensitivity and specificity for exudates detection was 80% and 99.5%, respectively. Balaji K and Juby N Zacharias [2] have compared the Fuzzy K Means and Fuzzy C-Means algorithm for Thyroid gland data obtained by Dr. Coomans. As a result of clustering algorithms, patients statuses are classified normal, hyperthyroid and hypothyroid function. They have concluded that Fuzzy C Means gives better results with correct classified samples than Fuzzy K Means algorithm in medical diagnostic system. Dunn [3] has developed Fuzzy C-Means (FCM) clustering and it was improved by Bezdek [4]. The Fuzzy C-Means (FCM) clustering is a popular clustering technique for image segmentation. Goh et al. [5] have experimented the minimum distance discriminant method to detect the exudates. Hsu et al. [6] presented a domain knowledge based approach to detect exudates. A median filter is used to measure an intensity difference map. Dynamic clustering is used to determine lesion clusters. Kavitha et al. [7] have conducted a series of experiments on classification of hard and soft exudates. The colour fundus retinal images are subjected to reprocessing for CIE Lab colour space conversion and Fundus region detection using binarization and mathematical morphology respectively. The optic disc is detected and localized with the aid of region props and colour histogram. Exudates are detected with the aid of thresholding colour histogram, which is used to classify the hard and soft exudates pixel from the colour fundus retinal image. Sai Deepak et al. [9] proposed a two-stage methodology for the detection and classification of DME severity from colour fundus images. DME detection is done via a supervised learning approach using the

normal fundus images. A feature extraction technique is used to capture the global characteristics of the fundus images and discriminate the normal from DME images. Disease severity is detected using a rotational asymmetry measure by examining the symmetry of macular region. The detection performance has a sensitivity of 100% with specificity between 74% and 90%. Jebarani et al. [10] extracted Texture Features: Mean- average intensity, Standard deviation- average contrast, Relative Smoothness, Uniformity, Entropy- measure of randomness. Optic Disc was segmented using Fuzzy C-Means (FCM) clustering. They were unable to deal with the problems of varying image quality, such as contrast and brightness. Lili Xu and Shuqian Luo in [11] used a Support Vector Machine classifier to identify hard exudates from digital retinal images. Priya.R, et al. [12] used Fuzzy C Means Clustering (FCM) for segmenting the blood vessels. They have compared the classifiers Probabilistic Neural Network (PNN) and Support Vector Machine (SVM) for the diagnosis of Diabetic Retinopathy.

3. PROPOSED WORK

This section outlines the objective and methodology used for the assessment of Diabetic Macular Edema. The main objective is to:

- Enhance the Hard Exudates regardless of their size.
- Classify the normal and abnormal images
- Evaluate the performance of the Diabetic Macular Edema detection method.

Diabetic Macular Edema (DME) is generally detected directly or indirectly. Direct method is by using ophthalmoscopy for manual examination. Since quality assurance is difficult for manual assessment the indirect method is opted. Detecting the presence of hard exudates (HE) in different areas of retina is now considered as an indirect method to assess Diabetic Macular Edema (DME) from colour fundus images. In this paper an automated approach for the assessment of Hard Exudates is presented. The block diagram for the detection of hard exudates is shown in Fig. 1.

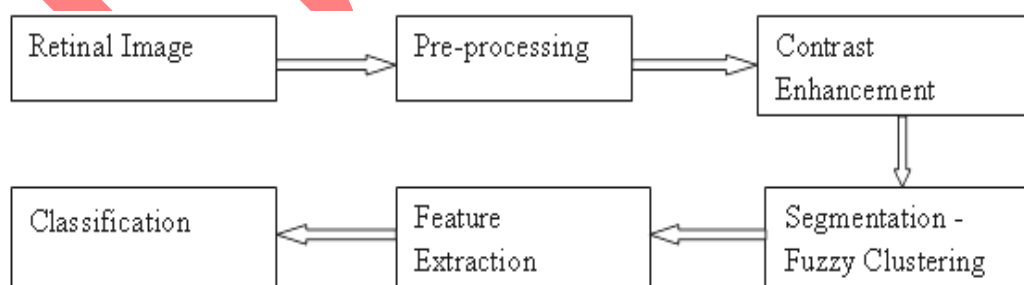


Fig.1 Block Diagram for Detection of Hard Exudates

The following section describes about the Fuzzy Image Processing and the reasons for selecting this tool for diagnosis.

Fuzzy Image Processing

Fuzzy Image Processing techniques serves as a tool for automated detection of DME, which assists the medical experts in diagnosis of the disease.

1) *Need for Fuzzy Image Processing*: In the medical field, the Doctors diagnose the patient by physical examination, the symptoms the patient describes, by referring to the case history of the patient, scan reports, laboratory results etc. He cannot completely rely on this information for treatment, because the information is not fully accurate. There exists varying degrees of uncertainty, imprecision, vagueness in the information obtained. This infers that, the state and symptoms known by the doctors is only with a limited degree of precision. This prompted attempts to use Fuzzy sets in Image Processing. These models help the medical experts in the diagnosis of specified categories of disease.

3.1 Acquisition of Retinal Images

Retinal Images are acquired from the MESSIDOR dataset. The MESSIDOR dataset comprises of macula centred colour fundus images (1200), acquired at multiple resolutions, of patients showing different symptoms of DR. All the abnormal images are obtained at Serviced'Ophthalmologie-Hopital Lariboisiere Paris. Some of these images are used.

3.2 Preprocessing Stage

In detecting abnormalities associated with fundus image, the images have to be pre-processed in order to correct the problems of uneven illumination problem. The image noise is reduced, and contrast enhancement is made in the preprocessing stage. The techniques involved are Median Filtering, Contrast Limited Adaptive Histogram Equalization.

Median filter

Median filter is a nonlinear digital filtering method, often used to remove noise. That noise reduction is a typical pre-processing step to improve the results of later processing (for example, edge detection on an image). It is very widely used in digital image processing because it preserves edges while removing noise, under certain conditions.

3.3 Contrast Enhancement

Images having low contrast can result from inadequate illumination, wrong lens aperture settings, or lack of dynamic range in the imaging sensor. Contrast enhancement increases the dynamic range of an image. Contrast Limited Adaptive Histogram Equalization is used to improve contrast in the images.

3.4 Segmentation-Fuzzy Clustering

Segmentation is used with the intention of simplifying or adjusting the representation of the image for ease of understanding. Segmentation refers to the process of partitioning a digital

image into multiple regions. The aim of segmentation is to simplify the representation of an image into something that is more meaningful and easier to analyze. We have chosen Fuzzy clustering algorithm for the segmentation of Hard Exudates. In real applications there is very often no sharp boundary between clusters so that fuzzy clustering is often better suited for the data. Exudates region will be clearly detected and it will give best result for overlapped data set.

4.FEATURE EXTRACTION

The purpose of feature extraction is to reduce the original data set by measuring certain properties or features that distinguish one input pattern from another pattern. The next step in this paper is to extract a set of features for each region and classify the region as exudates and non exudates based on the generated feature vectors. Abdolhossein Fathi et al. [13] have used Local Binary Pattern (LBP) as texture descriptor to extract the features of Blood vessels and Adaptive neuro-fuzzy inference system for classification. Loris et al. [14] used Local Binary Pattern (LBP) as texture descriptor for representation of Biomedical Images. Their future work is to study the performance of the proposed texture descriptors when the feature extraction is performed from images that have been pre-processed using the different methods (e.g. Gabor filters).T. Ojala et al. [15] considered the joint occurrences of LBP and contrast in a 3x3 neighbourhood. LBP texture operator has become popular nowadays in various applications like face recognition, texture analysis, Pap smear test, etc. We have used LBP operator to extract the features from the fuzzy clustered segmented images, due to its computational simplicity, efficiency and robustness to illumination variations.

5.CLASSIFICATION FOR RETINAL IMAGE

The local binary pattern features are input to the classifier to classify the retinal images as Normal and Abnormal. We have chosen the Support Vector Machine (SVM) classifier for classifying the images. SVM described by Vapnik [19] is a robust technique for data classification. SVM is widely used in object detection & recognition, content-based image retrieval, text and speech recognition, biometrics, etc. SVM has better classification performance to a limited training set and it has good generalization ability. The classification task involves separating data into training and testing sets and to predict the labels of new input data. The performance of classification was evaluated by computing sensitivity, specificity and Accuracy. Sensitivity = $TP/TP+FN$, Specificity = $TN/TN+FP$, Accuracy = $TP+TN/TP+FN+TN+FP$.

TP: True Positive, Classification result is positive in the presence of exudates.

TN: True Negative, Classification result is negative in the absence of exudates.

FP: False Positive, Classification result is positive in the absence of exudates.

FN: False Negative, Classification result is negative in the presence of exudates.

6.RESULTS

In this paper the retinal image obtained is preprocessed using Median Filtering and Contrast Limited Adaptive Histogram Equalization Techniques. The Fuzzy Clustering algorithm used helps to automatically segment the exudates pixels.

Fig. 1 is the input retinal image obtained from messidor dataset, which contains hard exudates.



Fig. 1 Input Retinal Image which contains Hard Exudates

Fig. 2 is the image obtained after using median filtering technique, which helps to preserve edges.

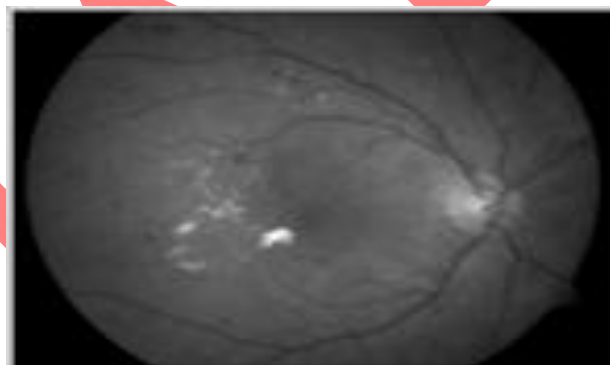


Fig. 2 Filtered Image

Fig. 3 is the Histogram Equalized image. As a result of contrast limited adaptive histogram equalization the dark area in the input retinal image that was badly illuminated has become brighter in the retinal image while the side that was highly illuminated reduces in brightness so that the whole illumination of the image is even.

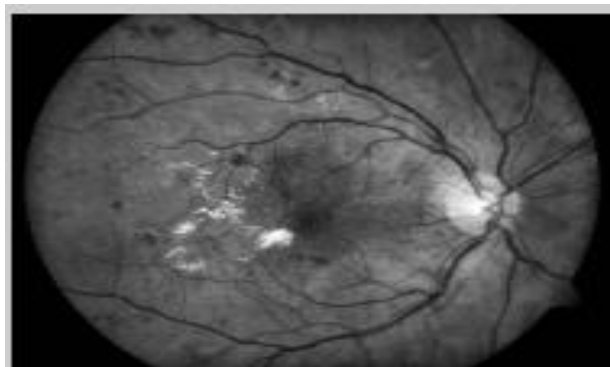


Fig. 3 Histogram Equalized Image

Fig. 4-5 illustrates Fuzzy Clustered Images and corresponding Local Binary Pattern Images. The Hard Exudates are segmented using Fuzzy Clustering algorithm, and the features are extracted using Local Binary Pattern Operator.

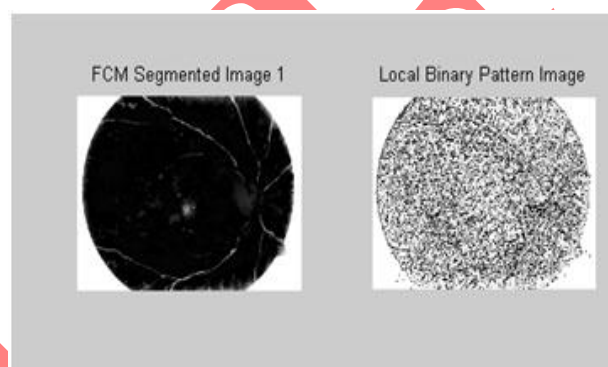


Fig. 4 Fuzzy Clustered and Local Binary Pattern Image1

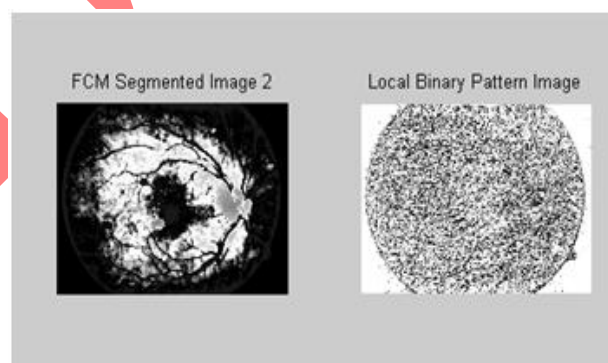


Fig. 5 Fuzzy Clustered and Local Binary Pattern Image2

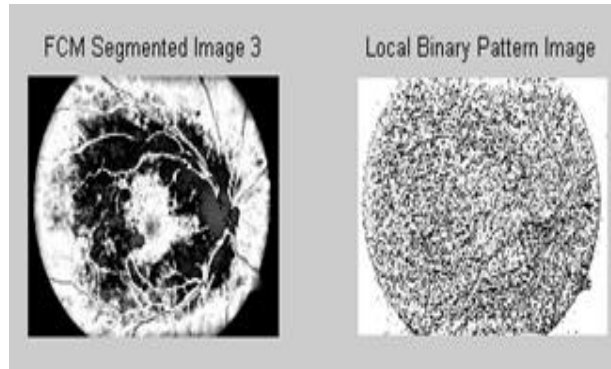


Fig. 6 Fuzzy Clustered and Local Binary Pattern Image3

Fig.7 shows the result of SVM classifier in terms of sensitivity, specificity and accuracy.

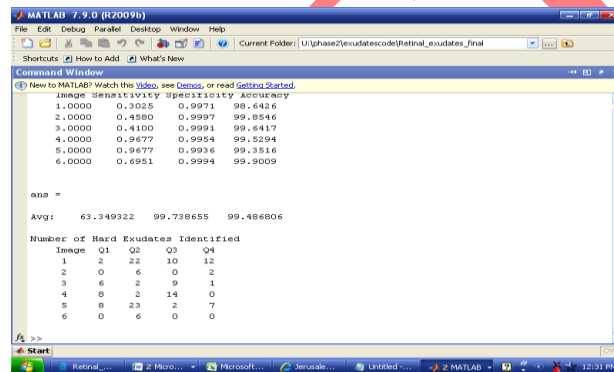


Fig. 7 SVM Classification Result

Fig 8 and Fig 9 shows the Normal and Abnormal Image which is classified using SVM Classifier.

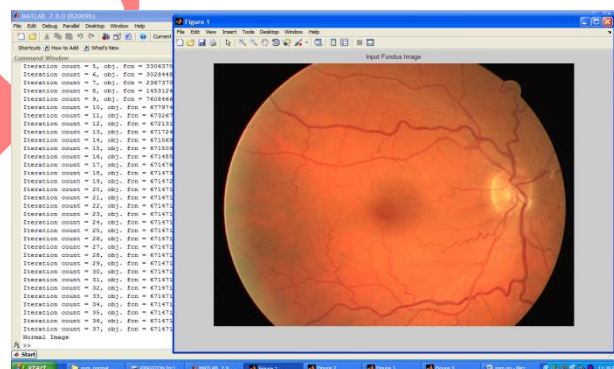


Fig. 8. Normal Image.



Fig. 9. Abnormal Image.

8. CONCLUSION AND FUTURE WORK

In this work, the input retinal image is preprocessed using Median Filtering and Contrast Limited Adaptive Histogram Equalization techniques, in order to improve the quality of the images. Fuzzy Clustering algorithm is used on the preprocessed images, which segments the Hard Exudates. The Local Binary Pattern (LBP) features are selected from the Fuzzy Clustered Images. The LBP features are input to the Support Vector Machine Classifier and the image is classified as Normal and abnormal automatically. Thus this automated approach of assessing Diabetic Macular Edema would minimise the time of medical experts while diagnosing in large scale scenario. Future work is to compare the performance of SVM classifier with another classifier and to use in real time application with more number of images.

REFERENCES

- [1] Akara Sopharak, Bunyarit Uyyanonvara, Sarah Barman, "Automatic Exudate Detection from Non-dilated Diabetic Retinopathy Retinal Images Using Fuzzy C-means Clustering" Journal of Sensors Vol.9 No.3 pp.2148-2161, 2009.
- [2] K. Balaji, and Juby N Zacharias, "Fuzzy C-Means" seminar at IITM-K, 2007.
- [3] J.C. Bezdek, "Pattern Recognition with Fuzzy Objective Function Algorithms" Plenum: New York NY USA, 1981.
- [4] J.C. Dunn, "A Fuzzy Relative of the ISODATA Process and Its Use in Detecting Compact Well- Separated Clusters" J. Cyber 32-57, 1973.
- [5] K.G. Goh, W. Hsu, H. Li Lee Wang, ADRIS, 'An Automatic Diabetic Retinal Image Screening system In Medical data mining and knowledge discovery" Krzysztof J.C. editor. Physica-Verlag: Heidelberg Germany pp. 181-210, 2001.

- [6] W. Hsu, P. Pallawala, M. L. Lee, and K.-G. A. Eong, "The role of domain knowledge in the detection of retinal hard exudates," in Proc. 2001 IEEE Comput. Soc. Conf. Comput. Vis. Pattern Recognit. (CVPR2001), 2001, vol. 2, pp. II-246–II-251.
- [7] S. Kavitha, K. Duraiswamy, "Automatic Detection of Hard and Soft Exudates in Fundus Images Using Color Histogram Thresholding", European Journal of Scientific Research ISSN 1450-216X Vol.48 No.3, 2011.
- [8] MESSIDOR Jun. 2011 [Online]. Available: <http://messidor.crihan.fr/index-en.php>.
- [9] K. Sai Deepak, Jayanthi Sivaswamy, "Automatic Assessment of Macular Edema From Color Retinal Images" IEEE Transactions on Medical Imaging VOL. 31 NO. 3, 2012.
- [10] Ms. P.N. Jebarani Sargunar, Dr. R. Sukanesh, "Exudates Detection and Classification In Diabetic Retinopathy Images By Texture Segmentation Methods" International Journal of Recent Trends in Engineering, Vol 2, No. 4, November 2009.
- [11] Lili Xu, Shuqian Luo, "Support Vector Macidne Based Method For Identifying Hard Exudates In Retinal Images", IEEE, 2009.
- [12] Priya.R , Aruna.P, "SVM and Neural Network based Diagnosis of Diabetic Retinopathy", International Journal of Computer Applications (0975 – 8887) Volume 41– No.1, March 2012.
- [13] Abdolhossein Fathi, Ahmad Reza Naghsh-Nilchi, "Integrating adaptive neuro-fuzzy inference system and local binary pattern operator for robust retinal blood vessels segmentation" Springer-Verlag London Limited 2012.
- [14] Loris Nanni, Alessandra Lumini, Sheryl Brahmam, "Local binary patterns variants as texture descriptors for medical image analysis", www.elsevier.com/locate/aiim.
- [15] T. Ojala, M. Pietikäinen, and D. Harwood, "A Comparative Study of Texture Measures with Classification Based on Feature Distributions", Pattern Recognition, vol. 29, pp. 51-59, 1996.
- [16] Shu Liao and Albert C. S. Chung, "Texture Classification By Using Advanced Local Binary Patterns And Spatial Distribution Of Dominant Patterns", 1424407281/07/\$20.00 ©2007 IEEE, ICASSP 2007.
- [17] Zhenhua Guo, Lei Zhang, and David Zhang, "A Completed Modeling of Local Binary Pattern Operator for Texture Classification", IEEE transactions on image processing, vol. 19, no. 6, June 2010.

- [18] Ms. P.N. Jebarani Sargunar, Dr.R.Sukanesh, “Exudates Detection and Classification In Diabetic Retinopathy Images By Texture Segmentation Methods”, International Journal of Recent Trends in Engineering, Vol 2, No. 4, November 2009.
- [19] Vapnik V “Statistical Learning Theory” Wiley, New York, 1998.

IJAER