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A Novel Method for Image Analysis and Exudates Detection in Retinal Images

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ABSTRACT

Diabetic retinopathy (DR) is one of the pre-eminent causes of blindness among the diabetic affected patient. DR is caused by the sensitive tissue in the retina because of the damaged blood vessels. Early detection of DR can potentially reduce the risk of blindness and it could be prevented with an early screening process .In this paper authors have attempt to develop an automated exudates detection system for the classification of retinal image into exudates and non-exudates using PNN classifier. The methodologies involved in this work are Pre-processing, Optic disc elimination, Segmentation of exudates using K-means clustering technique, to classify these segmented images into exudates and non-Exudates image, a set of features based on texture and color are extracted using Gray Level Co-Occurrence Matrix (GLCM). Feature selection is done using Genetic Algorithm, and then these selected features are classified into exudates and non-exudates using Probabilistic Neural Network (PNN) classifier with an accuracy of 96.9%.

Keywords: *Diabetic Retinopathy; Exudates; K-Means; GLCM; Genetic Algorithm; PNN.*

1.0 Introduction

Diabetes is a group of metabolic diseases in which a person has high blood sugar, either because the body does not produce enough insulin, or because the cells do not respond to the insulin that is produced. Diabetic retinopathy is one of the common complications of diabetes. Tiny blood vessels within the retina leak blood or fluid. The leaking fluid causes the retina to swell or to form deposits called exudates and this exudate is the important symptom of the Diabetic Retinopathy. Fig 1.2 shows the retinal image with exudates and Fig 1.1 shows the normal retinal image. Early detection of DR can potentially reduce the risk of blindness and it could be prevented with an early screening process. In this paper, an automated approach for detection of exudate in retinal images is presented. Retinal images were collected from DIARETDB0 [1],DIARETDB1 [2], DRIVE [3] and STARE [4] database and also live images from The Eye Foundation hospital, Coimbatore. Image Data set contains 130 retinal images in which 100 retinal images contain exudates and 30 are normal images.

2.0 Related Work

Many automated exudates detection system have been developed in medical and engineering fields. Various machine learning classifiers have been tried for the detection of exudates. A.Elbalaoui et.al [6] proposed a method of Segmentation and Detection of Diabetic Retinopathy Exudates. A fast method of segmentation and recognition of exudates for diabetic retinopathy based on graph cut and Neural Network is proposed. This approach will be used to improve the precision of the diagnosis of the diabetes retinopathy before the stage of complications. First step is pre-processing operation to improve image quality. In the second step optic disc is eliminated. In the third step, the segmentation of graph cuts is used to detect exudates regions. Finally, the neural network gives better results with a feature extraction of images by descriptors. Performances of the method are measured by Specificity 95%, sensitivity 96.65% value and accuracy 95.15% .Annie et.al [5] proposed a method for exudates detection using clustering algorithm. Pre-processing steps includes transformation of RGB

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to HSI color space, median filtering is applied to reduce noise and CLAHE is applied on intensity component of the image. Image segmentation is based on K-means clustering method. The regions are classified into five clusters using K-means clustering algorithm. Optic disc is eliminated. To classify segmented image into exudates and non-exudates a number of features are extracted using GLCM. These selected features are classified as exudates and non-exudates using SVM classifier with an accuracy of 96%.Wawan Setiawaet.al[13] proposed a method of Image Classification With Probabilistic Neural Network (PNN) Approaches. The design of classifiers with neural network based on the method Expectations Maximum (EM) is presented. In this particular, the multilayer perceptron neural network model with Probabilistic Neural Network (PNN) is used for nonparametric estimation of posterior class probabilities. Based on experimental results on two test areas can be shown that the average accuracy rate PNN classifier is better than the Back Propagation (BP), and the Expectation Maximum (EM) increase the ability of classifiers. Classification accuracy was roughly comparable, back propagation produced 93.91% whereas PNN produced 95.82% over all accuracy. Babatunde Oluleye et.al [17] presented the details of exploration and applications of Genetic Algorithm (GA) for feature selection. Particularly a binary GA was used for dimensionality reduction to enhance the performance of the concerned classifiers. In this work, 100 features were extracted from set of images found in the Flavia dataset (a publicly available dataset).

The main contributions of this article are detailed documentation of the GA Toolbox in MATLAB and the development of a GA-based feature selector using a novel fitness function (KNN-based classification error) which enabled the GA to gain a reduced set of feature giving rise to optimal accuracy.

Fig 1: Normal Retinal Image

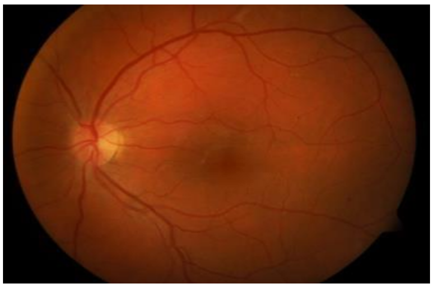
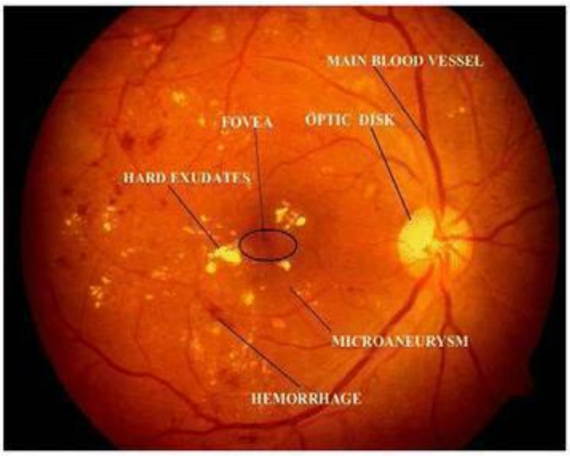


Fig.2: Retinal Image with Exudates



3.0 Methodology

The methodology adopted in this work is schematically shown through a flow diagram in figure1 and the steps are briefed in the following paragraph.

3.1 Image acquisition

In this work, Retinal images were collected from DIARETdb1, DRIVE and STARE database and also live images from The Eye Foundation hospital, Coimbatore. Image Data set contains 130 retinal images in which 100 retinal images contain exudates and 30 are normal images.

3.2 Pre-processing

After the image acquisition the work begins with the pre-processing method which includes the following methods: RGB to HSI conversion, Noise removal by median filtering and Adaptive Histogram equalization.

To separate the color components with intensity and brightness, the input retinal images of RGB color space are converted into HSI color space. The reason for selecting HSI color space is to separate intensity component from the other two components Hue and Saturation.

So, we get intensity information for the diagnosis of exudates. Figure 2 shows the conversion of RGB to HSI color space.

As a part of pre-processing, salt and pepper noise is added to the intensity component of HSI color space and filtered by applying median filter of 3 X 3 sizes.

Adaptive Histogram Equalization (AHE) is a processing technique used to improve contrast in images. AHE is applied on the intensity component of image which is median filtered.

Fig 3: Work Flow of Implemented Method

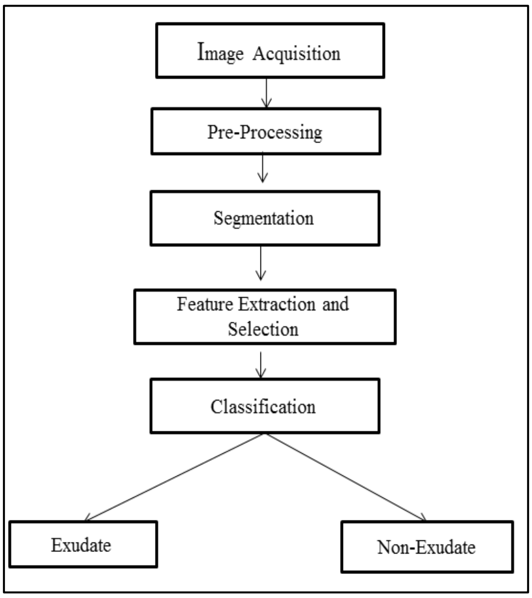
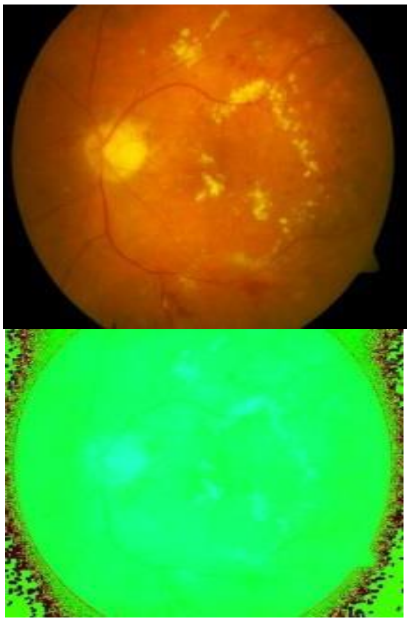


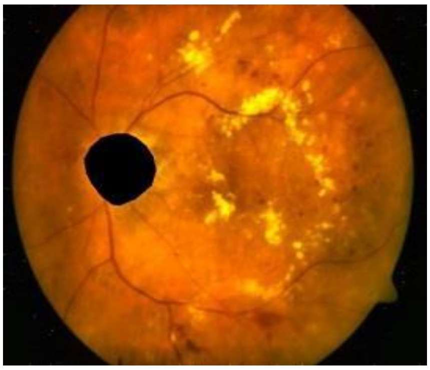
Fig 4: RGB to HSI Color Space



3.3 Optic disk elimination

Since optic disc has characteristics such as intensity similar to hard exudates, it is removed from the image to avoid false classification. So, optic disc elimination is important for correct segmentation of exudates. Then I component, in which optic disc is eliminated is combined with H and S components to convert again that into RGB color space. Fig 1.3 shows the retinal image in which optic disc is eliminated.

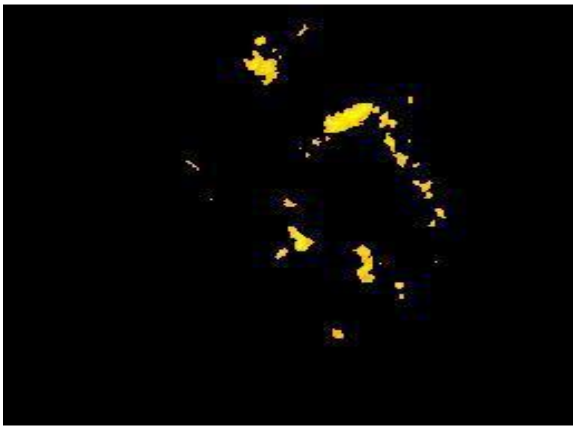
Fig 5: Optic Disc Eliminated RGB Image



3.4 Segmentation based on K-means

In this paper, image segmentation based on color features is presented. Segmentation refers to the process of partitioning an image into groups of pixels which are homogeneous with respect to some criteria. First, the color separation is done by extracting the a*b* components from the L*a*b* colour space of the pre-processed image [4]. Then, the regions are grouped into a set of seven clusters using K-means Clustering algorithm

Fig 6: Segmented Image



3.5 Feature extraction

To classify the segmented image into exudates and Non-exudates, a number of features based on color and texture are extracted using Gray Level Co-occurrence Matrix (GLCM).

GLCM is a matrix that calculates how often a pixel with gray-level (grayscale intensity) value i occurs horizontally adjacent to a pixel with the value j. A set of 20 textural features are extracted from the co-occurrence matrix, which contain image textural characteristics such as autocorrelation, contrast, correlation, cluster prominence, cluster shade, dissimilarity, energy, entropy, homogeneity, maximum probability, sum of squares, sum variance, sum average, sum variance, sum entropy, difference variance,difference entropy, information measure of correlation 1, information measure of correlation 2 and inverse difference moment normalized.

3.6 Feature selection

Homogeneity Feature selection, also known as variable selection is the process of selecting a subset of relevant features. In this work, Feature selection is done by using Genetic algorithm. GA is used for optimizing or selecting best features which gives a reduced feature set eventually results in high classification accuracy. Reducing the dimensions of the feature space not only reduces the computational complexity, but also increases estimated performance of the classifiers. The approach used here is that the textures features values that extracted from gray level co-occurrence matrix (GLCM) gives the typical values for features analysis. The Genetic Algorithm finds optimal Texture Features extracted from GLCM based on the fitness function. GLCM with 20 features are reduced to 9 most predominant features. The reduced feature set has following features:

- Contrast
- Correlation
- Cluster shade
- Dissimilarity
- Energy
- Entropy
- Homogeneity
- Sum variance
- Difference variance

3.7 Classification using probabilistic neural network (PNN)

A probabilistic neural network (PNN) is predominantly a classifier.PNN is an implementation of a statistical algorithm called kernel discriminate analysis in which the operations are organized into a multi-layered feed forward network with four layers:

- Input layer
- Pattern layer
- Summation layer
- Output layer

PNN main task is to classify unknown feature vectors into predefined classes where the Probability Density Function (PDF) is given by,

$$\frac{1}{n\sigma}\sum_{k=1}^{n} w\left(\frac{x-x_k}{\sigma}\right) \qquad (1)$$

Where, x = unknown (input), xk = kth sample, w = weighting function, σ = smoothing parameter. The feature vectors obtained from the feature selection are divided into train data and test data in the ration of 60 and 40 respectively and classified into exudates and non-exudates images using Probabilistic Neural network (PNN) classifier.

4.0 Results and Discussion

Data set contains 130 retinal images of which 100 images contains signs of Diabetic Retinopathy and 30 are normal images are used to develop this project.

The pre-processing of retinal images is done to improve the image quality. Since Optic Disc and Exudates are homogenous in color, optic disc is eliminated.

To extract the exudates K-means Clustering technique is used and the result consists of seven clusters. Cluster containing exudates is selected for feature extraction using GLCM. Feature selection is done to reduce feature set. The reduced feature set contains the following features:

- Contrast
- Correlation
- Cluster shade
- Dissimilarity
- Energy
- Entropy
- Homogeneity
- Homogeneity
- Difference variance

Table1 Reduced set of GLCM

	Correlation	Correlation	Cluster shade	Dissimilarity	Energy	Entropy	Homogeneity	Sum variance	Difference variance
1	0.088	6.896	0.018	0.985	0.063	0.996	4.636	0.088	-0.477
2	0.589	47.215	0.097	0.933	0.218	0.984	8.603	0.589	-0.473
3	0.035	6.118	0.006	0.993	0.026	0.998	4.511	0.035	-0.695
4	0.207	15.093	0.0467	0.962	0.149	0.989	5.511	0.207	-0.442
5	0.084	15.480	0.017	0.978	0.087	0.996	5.417	0.084	-0.651
6	0.274	16.356	0.050	0.968	0.121	0.991	5.597	0.274	-0.421

The table1 represents the reduced set of GLCM of 6 sample retinal images. The retinal input image is classified into two classes, whether the image is abnormal image or normal image. The classification accuracy of the analysis is assessed using the Accuracy.

$$\text{Accuracy} = \frac{TP+TN}{TP+TN+FP+FN} \qquad (2)$$

Where TP is the number of images that contains exudates classified as abnormal (images that contain exudates) images, TN is the number of normal images classified as normal, FP is the number of normal images classified as abnormal images and FN is the number of abnormal images classified as normal images. The selected features are classified into exudates and non-exudates images using Probabilistic Neural Network (PNN) classifier and exudates are detected with the classification accuracy of 96.9%.

5.0 Conclusions

In this paper, a method for exudates detection in retinal images is proposed. This approach will be used to improve the exactness in the diagnosis of the Diabetic Retinopathy (DR). Image pre-processing techniques are used to improve the image quality to eliminate defects caused by acquisition process. Elimination of optic disc in retinal images resulted in avoiding misclassification. Segmentation using k-means clustering technique proved to be efficient to extract exudates. Feature extraction using GLCM proved to be efficient to extract texture features. Feature selection is done using Genetic Algorithm to reduce feature set that reduces memory consumption and improves efficiency of the system. Selected features are classified into exudates and non-exudates using Probabilistic Neural Network (PNN) with an accuracy of 96.9%.

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