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EXUDATES DETECTION FROM RETINAL FUNDUS IMAGES USING PROBABILISTIC NEURAL NETWORK

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Abstract— **This paper presents an algorithm to automatically detect exudates in retinal images using Probabilistic Neural Network (PNN). Proposed algorithm consists of four main steps, in the first step pre-processing is done using Green channel extraction and Gaussian smoothing. In the second step feature extraction is done using Discrete Wavelet Transform (DWT). In the third step, Probabilistic Neural Network (PNN) is used to detect exudates and optic disk. Finally, optic disk is eliminated and actual exudates are detected.**

Keywords— **Exudates, Wavelet, PNN**

I. INTRODUCTION

Eyes are one of the most important parts of human body. There are many diseases due to which a person can lose his eyesight. One of the most common disease due to which most of the people around the world are losing their eyesight today, is diabetes. Diabetes is caused either due to the improper secretion of insulin from the pancreas or the cells of the body not responding properly to the insulin produced. Diabetes for a long period of time may lead to weakening of eyesight or even blindness in the patient. This condition is called Diabetic Retinopathy (DR).

DR is damage to the eyes caused due to the complications in diabetes. DR can be broadly classified into two phases: Non Proliferative Diabetic Retinopathy (NPDR) and Proliferative Diabetic Retinopathy (PDR) [1]. NPDR is asymptotic in nature and therefore it is very difficult to detect the disease in its early stages. PDR is the second stage in which the newly formed abnormal blood vessels which are fragile in nature may burst and bleed and can blur the vision, leaving behind few specks of blood in the retina. These specks form the pathological signs of the DR. Microaneurysm (MAs), Hemorrhages (HMs), exudates (EXs) and cotton wool spots are various pathological signs of DR. Microaneurysm (MAs) and Hemorrhages(HMs) are red lesion while exudates(EXs) and cotton wool spots are bright or white lesion. Hard exudates appear yellowish or white in color with different shapes and sizes due to the leakage of proteins or lipids from the damaged blood vessels in the retina.

Figure.1 shows the various components of an eye such as blood vessels, macula (centre portion of retina), fovea (centre portion of macula), optic disk and the exudates.

Lots of research work is being done in this field to automate the process of detecting exudates from the retinal fundus images. Researchers around the world have used various image processing techniques to develop an efficient algorithm .Computational intelligence based techniques uses fuzzy c-means clustering for segmentation. The segmented image is then classified into exudates and non-exudates based on the set of initial features such as color, size, edge strength, and texture. Finally, Multilayer neural network classifier is used to classify the selected feature vectors [2]**.**Differential Morphological Profile (DMP) based method uses Gaussian smoothing and contrast enhancement for pre-processing and applies DMP on the pre-processed image. The image containing exudates and optic disc is obtained after applying DMP. Finally, optic disk is removed based on its location, shape index and area to obtain actual exudates [1].

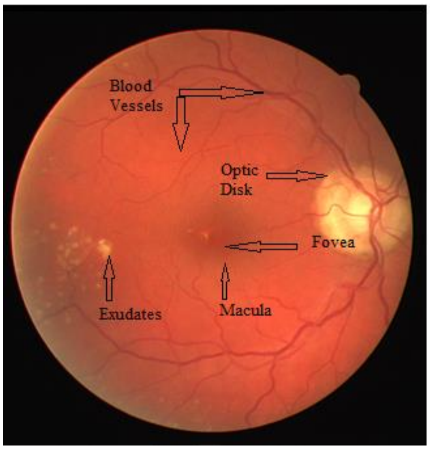

Fig.1 Human Eye Containing Exudates

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An Integrated Approach using Dynamic Thresholding and Edge Detection (IDTED) for Automatic Detection of Exudates combines pre-processing techniques such as histogram specification and local contrast enhancement with dynamic thresholding (DT) and edge detection. Principle Component Analysis (PCA) is used to localize the Optic disc (OD) and for accurate segmentation of boundary of OD Active contour based approach is used [3]. Feature-based method for early detection of exudates is based on segmenting objects that have contrast with the background including the exudates. The exudates could then be extracted after eliminating the other objects from the image. A new method based on simple morphological operations for extracting the blood vessel tree is proposed. Hough transform is used to obtain circular structure of the optic disc. To get an initial estimate of exudates, the regions representing the blood vessel tree and the optic disc are set to zero in the segmented image. Finally, exudates are obtained by morphological reconstruction [4].
An automated method based on Probabilistic Neural Network (PNN) classifier detects the DR by detecting exudates using Morphological process in color fundus retinal images and then segregates the severity of the lesions. The severity level of the disease is obtained using Probabilistic Neural Network (PNN) classifier [5].A method based on combination of stationary wavelet transform (SWT) and gray level co-occurrence matrix (GLCM) is used to characterize hard exudates candidates. Finally for classification, an optimized support vector machine (SVM) with Gaussian radial basis function is used [6].

II. PROPOSED ALGORITHM

The flowchart of the proposed method is shown in Figure 2. It shows how the progress is made to detect exudates from the retinal images. Following steps are followed in the given order to obtain the results:

A. *Input Image*

The method proposed in this paper is tested on the image taken from the DRIVE database [7]. DRIVE database consists of 40 images divided into training and testing dataset both consisting of 20 images each. The images were acquired using a Canon CR5 non-my driatic 3CCD camera with a 45 degree field of view (FOV).

B. Green Channel Extraction

Before applying any method for the detection of exudates from the retinal images, input image has to be pre-processed. Pre-processing an image removes unwanted noise and variations from the input image. It also increases the contrast and quality of the input image.

Images in RGB color space consists of three color channels red, green and blue. Exudates appear yellowish in RGB color space. Out of these three channels, green channel provides the highest contrast between the retinal background and the blood vessels. Other two channels do not contain much of information relevant for exudates detection, therefore green channel is extracted [1].

Input image I can be represented as:

1. $I = [\, I_R , I_G , I_B \,]$ (1)

Where I_R , I_G , I_B represents red, green and blue components respectively.

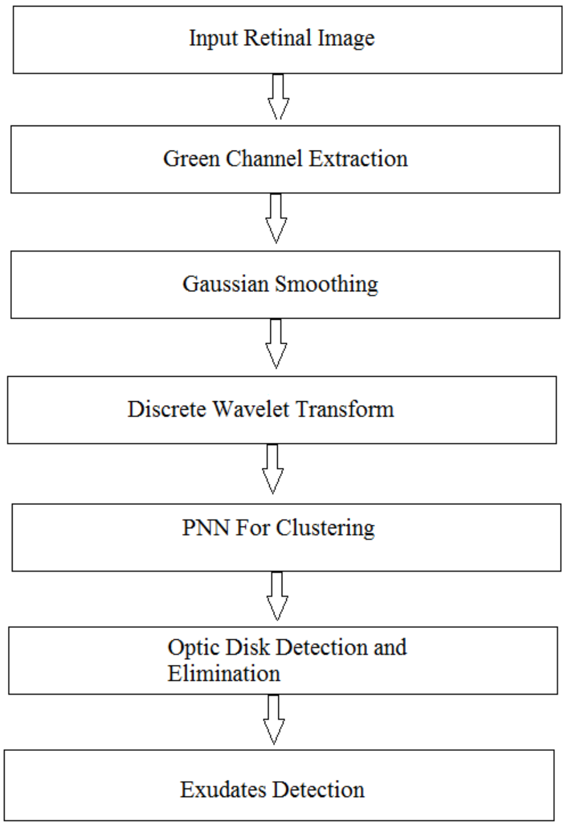

Fig.2 Flowchart Of Proposed Work

C. Gaussian Smoothing

Gaussian smoothing operator eliminates the illumination and noise effects by performing weighted average of neighbouring pixels based on Gaussian distribution. Gaussian low pass filter is applied on the extracted green component I_G to improve the quality of input image [1]. Thus,

$$I_{GS}(x\,,y) = I_G(x,y) * g(x,y) \quad (2)$$

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Where * represents the convolution operator and g(x,y) is the Gaussian function given by

$$g(x,y)=\frac{1}{2\pi\sigma^2}e^{\left(\frac{-x^2+y^2}{2\sigma^2}\right)} \qquad (3)$$

Where σ is the standard deviation

D. Discrete Wavelet Transform

DWT is one of the most widely used multiscale decomposition technique that provides better spectral and spatial localization of image formation as compared to other multiscale decomposition techniques. Figure 3 shows the one level decomposition of the image into four frequency bands LL(low- low),LH(low- high), HL(high- low) and HH(high-high).First quadrant in the figure 3, shows the next level of decomposition applied only to the LL band. Decomposing an image into N levels gives total of 3N+1 frequency bands out of which 3N high frequency bands are known as the details of the image and only one band on which low-low filter is applied is known as the approximation of the image[8].Numbers(1,2) in the figure represents the level of decomposition.

Here, 2-D DWT is used for feature extraction.

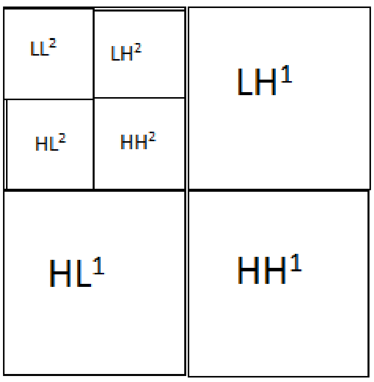

Fig.3 The structure of 2D DWT

E. Probabilistic Neural Network

PNN is a supervised neural network consisting of four layers:- Input Layer, Pattern Layer, Summation Layer and Output Layer. Figure 3 shows the architecture of the network.

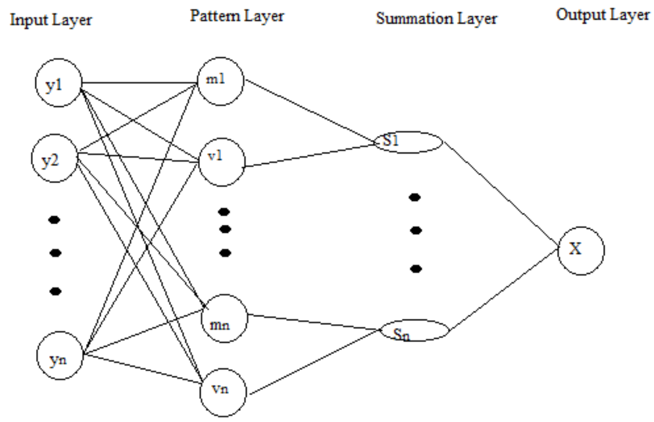

Fig.4 Architecture Of PNN

The image to be classified is given as input to the input layer. The mean values $m_1, m_2, \ldots, m_n$ and covariance matrices $v_1, v_2, \ldots, v_n$ of the classes $w_1, w_2, \ldots, w_n$ are computed using training vectors and these values are fed as input to the pattern layer. The Summation layer contains probability density function S as the estimator. Output layer gives the final image which contains features classified into different classes.

The probability density function of the pattern vector y of the class w_k is estimated as

$$f_y\left(\frac{y}{w_k}\right)=\frac{1}{(2\Pi)^{n/2}|v_k|^{\frac{1}{2}}}e^{\frac{-1\left[(y-m_k)^T v^{-1}(y-m_k)\right]}{2}} \qquad (4)$$

Where n is the dimensionality of the pattern vector y. m_k and v_k are the mean and covariance matrices of the class w_k and $|v_k|$ is the determinant of v_k.

Given a pixel z with the pattern vector y, it will be assigned to the class w_k by the PNN, if the following condition holds:-

$$P_k f_y\left(\frac{y}{w_k}\right) > P_j f_y\left(\frac{y}{w_j}\right) \quad \forall\ i \neq k \qquad (5)$$

Where P_k and P_j are the probabilities of occurrence of the pattern in the class w_k and w_j respectively [9].

F. Optic Disk Detection and Elimination

The image obtained after applying PNN for classification contains candidate exudates which may also contain some false detection .Some filtering technique needs to be applied to filter the exudates. Optic disk is also detected as exudates due to its spectral similarity with the exudates. To obtain the actual exudates, optic disk needs to be detected and eliminated. Shape and size of the optic disk can be used to differentiate it from the exudates. Optic disk is bigger than exudates and also it is circular in shape. Gaussian filter is applied to the image to smoothen it and then it is thresholded to obtain an image with optic disk highlighted in it. Based on the area and shape index (SI) of the optic disk, it is eliminated. SI can be defined as the ratio of the area of the candidate exudates over the square of the length of its boundary.

$$SI\ (I_{CN}) = 4\pi \frac{area(I_{CN})}{Perimeter(I_{CN})^2} \qquad (6)$$

Where area (I_{CN}) $=\iint dxdy$ and x,y $\epsilon\ I_{CN}$.

Number of pixels in the given region gives the area of that region. Objects having larger area than predefined are removed. These objects are nothing but optic disc [1].

G. Exudates Detection

Candidate exudates passing the area and shape index criteria are identified as the exudates. At the end logical "OR" operator is used to integrate the exudates together to get the actual exudates.

III. EXPERIMENT AND RESULT

The method proposed in this paper is implemented in MATLAB R2013a. Figure 5 shows the original input image.

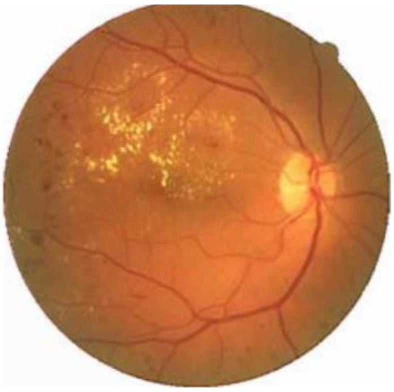

Fig.5 Original image

The results obtained after each step are shown in figure 6(a)-(e).Fig.6(a) and (b) shows the results obtained after green channel extraction and Gaussian smoothing.Fig.6 (c) shows the result obtained after applying DWT. Results obtained after classification are shown in fig.6(d). Fig.6(e) and (f) shows the image obtained after optic disk detection and removal and finally actual exudates are shown in fig.6(f).

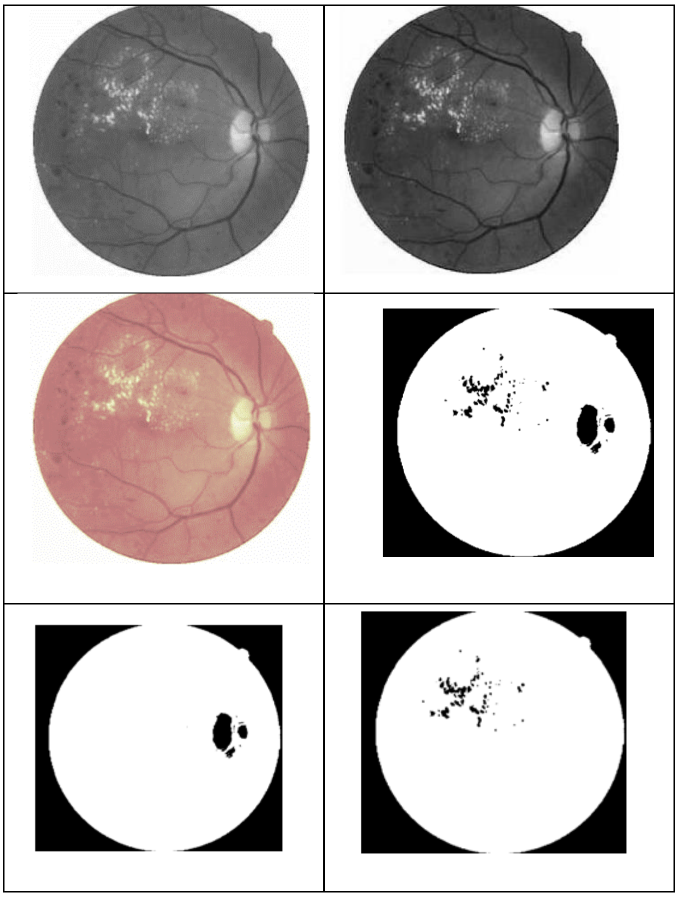

Fig. 6. (a) Green Channel Extraction (b) Gaussian Smoothing (c) DWT synthesized image (d) Classified image (e) Optic disk detection (f) final result The proposed method is quantitatively analyzed using images from DRIVE database [7].Table 1 shows the comparison of results obtained with other two papers.Table 1 compares the results with the other related work in the literature.

Table -1 Experiment Result

Method	Specificity	Sensiti vity	P PV
Kande.G.B.et.al	98%	86%	9 3%
Osareh.et.al	94.6%	96%	9 4%
Proposed Method	95%	97%	9 6%

IV. CONCLUSION

This paper presents a method that can automatically detect exudates from the retinal images using PNN. Certain pre-processing methods such as Green channel extraction and

Gaussian smoothing are used to improve the quality of the input image. PNN is used to highlight the exudates and optic disk. Optic disk is removed using its area, shape index and location to get the actual exudates.

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