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A Study on Segmentation and Feature Extraction of Retinal Images using Fuzzy C-Means Clustering

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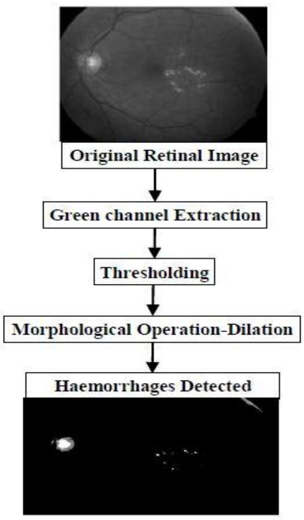
Abstract: *One of the major problem occur due to diabetes is retinopathy. It should be diagnosed earlier for effective treatment. In the initial stage of diabetes, patient may suffer in the earlier stage of diabetic retinopathy which gives the symptoms of starting of vision deteriorate in retina. This symptoms result to the eye deficiency in any one of the type of retinopathy. But the survey of medical refers that many people get affects by non-proliferative retinopathy and proliferative retinopathy. There are many ways to diagnose this eye deficiency. This process uses the digital image processing for filtering the noise in the image and it can be seen at different angle by using digitization method. Each image can be compressed by using Discrete Wavelet Transform method. The blood vessels are segmented using FUZZY C-Means.*

Keywords: Diabetic Retinopathy, Fuzzy C-Means, Discete Wavelet Transform

I. INTRODUCTION

Diabetic retinopathy occurs in the case of damage in blood cells in retina which leads to the loss of vision. It severely attacks the age group of middle age and older people of diabetes. There are six types of retinopathy. They are retinopathy of prematurity which occur for the baby who born prematurely or at a low birth weight, diabetic retinopathy which occur during the normal diabetes types as type-1 and type-2,non-proliferative retinopathy which occur due to the leaking of fluids in the blood vessels in retina which also leads to impairment of vision problem, proliferative retinopathy which occur due to the growth of unstable blood vessels in retina which also leads to retinal detachment, hypertensive retinopathy which occur for the people who suffers from high blood pressure and central serous retinopathy which occur due to the fluid staged in behind the retina which leads to blurred vision or poor night vision.

II. METHODOLOGY



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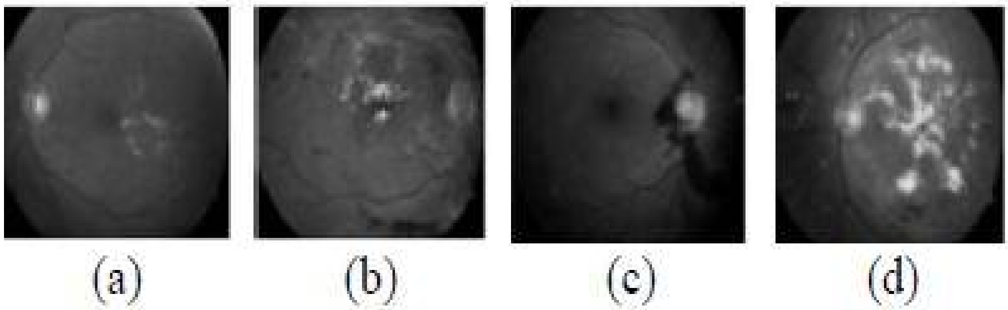
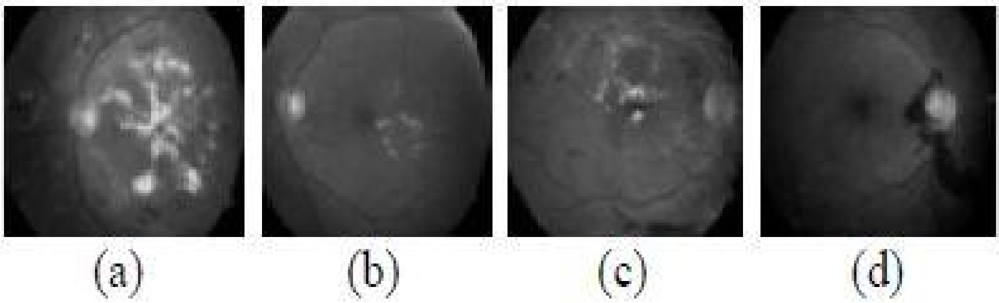
III. PREPROCESSING OF IMAGES

An image is to be preprocessed by correcting the unordered illumination, by adjusting the contrast between NPDR and DPR and image background pixels and the presence of noise in the input fundus image.

IV. GRAY SCALE CONVERSION

The image resolution is 1280 × 1024 in 24bit JPEG/JPG format. This gray scale conversion takes the colored image as an input and produces the output as gray scale image.





V. HISTOGRAM EQUALIZATION

For the improvement of contrast in the gray scale converted image, Histogram equalization is used. Consider an image W of N × N pixels centered on a pixel P(i, j), the image is filtered to produce another sub image P of (n x n) pixel.

$$P_n = 255\left(\frac{[\emptyset_w(P) - \emptyset_w(Min)]}{[\emptyset_w(Max) - \emptyset_w(Min)]}\right)$$

$$where, \qquad \emptyset_w(P) = \frac{1}{\left[1 + exp\left(\frac{\mu_w - P}{\sigma_w}\right)\right]}$$

where Max denotes the maximum intensity value and Min denotes the minimum intensity value and μ_w indicate the local window mean and σ_w indicate standard deviation which are defined as,

$$\mu_w = \frac{1}{N^2}\sum\nolimits_{(i,j)\varepsilon\,(k,l)} P(i,j)$$

$$\sigma_w = \sqrt{\frac{1}{N^2}\sum\nolimits_{(i,j)\varepsilon(k,l)} (P(i,j) - \mu_w)^2}$$

As a result of this adaptive histogram equalization, the dark area in the input eye image that was badly illuminated has become brighter in the output eye image while the side that was highly illuminated remains or reduces so that the whole illumination of the eye image is same as shown in following figure.

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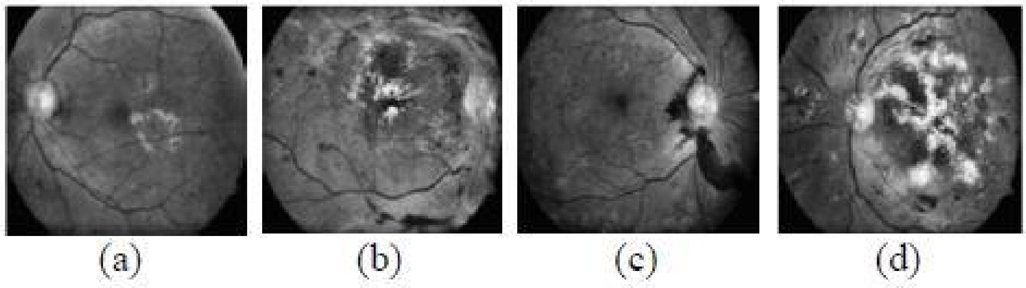
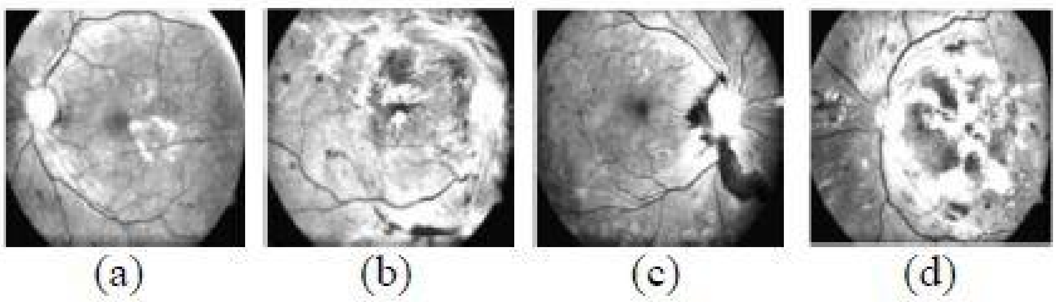


VI. DISCRETE WAVELET TRANSFORM (DWT)

Different representation of the signal can be made by the little transformation of the signal, without changing any information produce by the signal. It is based sub-band coding and theextract features of DWT are transformation of wavelet is fast, reduction in the computation time and required resources are available. This transformation will decompose a signal into wavelets which is obtained from a single prototype wavelet ψ(t),

$$\varphi_{a,b}(t) = \frac{1}{\sqrt{a}}\varphi\left(\frac{t-b}{a}\right)$$

where, 'a' denotes the values of scaling parameter and 'b' denotes the values of shifting parameter. As a result of applying this DWT to the eye images, the size of the images is reduced to half 640 × 512 without any change in the information content of an image. The resulting images are shown in following figure.



VII. THE MATCHED FILTER RESPONSE (MFR)

MFR is used for increase or maximize the image signal into noise ratio with the help of additional stochastic. The optimal filter is given by,

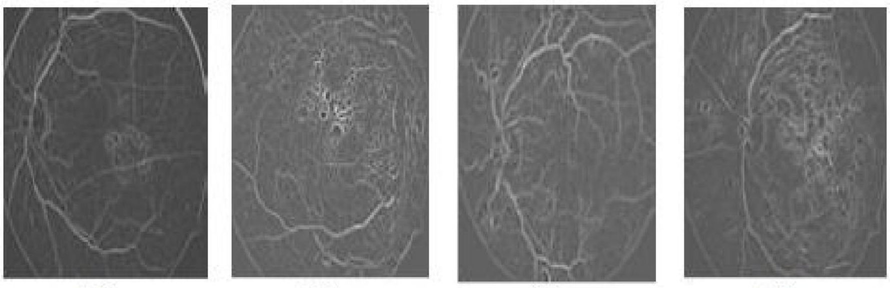
$$h_{opt}(d) = -exp\left(\frac{-d^2}{2\sigma^2}\right)$$

The negative sign occurs only when the blood vessels are darker when compared to the background of the image. Mathematical expression of Kernel is,

$$K(x,y) = -exp\left(\frac{-d^2}{2\sigma^2}\right)$$

For $|y| \leq L/2$

where, L denotes the length of the vessel segment, σ denotes the spread of the intensity range. The square shape is used for the kernel. A maximum of twelve kernels was used to rotate by an amount of 15^0 to detect blood vessels. As a result of applying this MFR to retinal images, response due to the noise is suppressed significantly, where no blood vessel is present as shown in following figure.



(a) (b) (c) (d)

VIII. THE FUZZY C-MEANS SEGMENTATION (FCM)

Since FCM is a fundamental clustering function, it specifically permits just one piece of information and requires that it belong to numerous clusters. By identifying the blood vessels in the retina and eyeball, FCM is primarily used in this DR detection to segment the image and identify the range of the DR. The primary purpose of FCM is

$$J_m = \sum_{i=1}^{N}\sum_{j=1}^{C} u_{ij}^{m} \left\|x_j - c_j\right\|^2, 1 \leq m < \alpha$$

where, m is the fuzzy co-efficient , any real number greater than 1, $u_{ij}$is the degree of membership of $x_j$in the cluster j, $x_i$is the $i^{th}$of d-dimensional measured data, $c_j$is the d-dimension center of the cluster, and ||*|| is any norm expressing the similarity between any measured data and the center.

The algorithm is composed of the following steps,

Step 1: Initialize U = [u_{ij}] matrix, U(0)

Step 2: At k-step: calculate the centers vectors C(k) = [c_j] with U(k)

Step 3: At k-step: calculate the centers vectors C(k) = [c_j] with U(k)

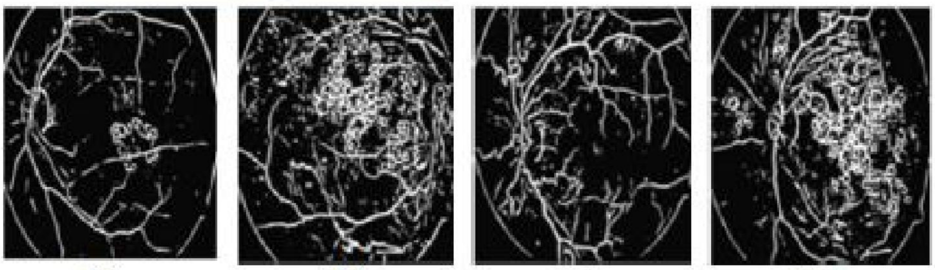
$$C_j = \frac{\sum_{i-1}^{N} u_{ij}^{m}.}{\sum_{i-1}^{N} u_{ij}^{m}} x_i$$

Step 4: Update U(k) , U(k + 1)

$$u_{ij} = \frac{1}{\sum_{k-1}^{c}\left(\frac{\|x_i - c_j\|}{\|x_i - c_k\|}\right)^{\frac{2}{m-1}}}$$

Step 5: If || U(k + 1) – U(k)|| <ε then STOP; otherwise return to step 2.

Here we have taken m = 2 and ε = 0.3. The resulting images after applying Fuzzy C-means Segmentation is shown in following figure.



(a) (b) (c) (d)

IX. FEATURE EXTRACTION

In retinopathy photos, haemorrhages and exudates both show up as bright lesions with crisp edges and strong contrast to the background. Using thresholding and morphological processing methods, we detect exudate border. The block diagram for haemorrhages or exudates detection is shown in the following figure. To find the haemorrhages or exudates, the subsequent methods are used.

X. GREEN COMPONENT

The fundus camera captures an RGB image of the retina. Because exudates appear most contrasted in the green channel of the RGB space, it is isolated and chosen for exudate identification. In order to create a new image, this channel must first be separated.

XI. THRESHOLDING

Thresholding is a straightforward form extraction method, and the images produced might be seen as the outcome of an effort to distinguish the eye from the background. The process of thresholding creates homogenous areas inside a picture based on a threshold criterion, T. The T is characterised by,

$$T = T\{x, y, A(x, y), f(x, y)\}$$

where, f (x, y) is the gray level of the pixel at (x, y) and A(x, y) denotes some local property in the neighborhood of this pixel.

A thresholded image,

$$g(x, y) = 1 \; if \; f(x, y) \geq T$$
$$g(x, y) = 0 \; if \; f(x, y) < T$$

A local thresholding method divides the provided image into sub-images and establishes a threshold for each of them.

$$T = T\{A(x, y), f(x, y)\}$$

where T depends on the pixel's grey-level value as well as a neighbourhood property. Thresholding's primary function is to highlight high wavelet coefficient values that almost correlate to the optic disc and to suppress low values that roughly correspond to noise or insignificant image elements. Local thresholding is used on the morphologically deteriorated image.

XII. MORPHOLOGICAL PROCESSING

Erosion will happen and result in boundary modifications if the user removes or makes any other changes to the pixels at the edges by modifying the binary values of 1. The removal or modification of boundary edges is a structural element carried out by the kernel.

XIII. FEATURE VALUES

Feature value range for DR

Features / Types of Eye Images	Radius (cm)	Diameter (cm)	Area (cm^2)	Arc Length (cm)	Centre angle (∅)	Half Area (cm^2)
Normal	144-156	260-320	65-80	5.7-7.6	2.2-2.6	32-39
NPDR	311-346	625-643	304-324	60.9-63.6	10.6-11.3	249-254
PDR	421-426	843-854	558-572	143-148	19.4-19.8	279-284

XIV. CONCLUSION

Diabetic Retinopathy is a disease which affects the vision. For the process of the functions input color retinal images are fed for the preprocessing techniques like Gray scale conversion, Histogram Equalization, Discrete Wavelet Transform, Matched filter Response and Fuzzy C-means segmentation are applied. The qualities of the images are improved only after the preprocessing functions processed successfully in the input image.

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