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Research Article

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Novel approach for retinal blood vessels extraction and exudates segmentation

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ABSTRACT

The complication of blood pressure and diabetes can affect various parts of the body. Diabetes and high blood pressure are major causes of blindness in the world. Due to high blood pressure and blockage in the blood flow causes swelling in ocular fundus which may leads to the formation of exudates. To diagnose the swelling in the retinal blood vessels and extract the features various methods are already proposed which are not clear. This paper proposes an efficient extraction of blood vessels and segmentation of exudates. In the proposed technique, the retinal image is initially super-resoluted and then the green plane is separated for accurate vessel extraction. Morphology operators using multi structure elements are applied to the enhanced image in order to find the retinal image ridges and reconstruction is performed to eliminate the ridges that are not belonging to the vessel tree while thin vessels remain unchanged. Segmentation using fuzzy clustering technique is performed for exudates detection.

Keywords: Fuzzy clustering, Morphology operators, Super resolution.

INTRODUCTION

Diabetic retinopathy is considered as a retinal vasculature disorder that occurs in majority of the patients with diabetes mellitus [1]. Although the diabetes cannot be prevented by itself it can be diagnosed in early stages to avoid complications. According to the estimation made by World health organization (WHO), the number of adults with diabetes would increase from 135 million in 1995 to 300 million in 2025 [2]. Advanced version of fundus camera is DRS which is a non-mydriatic fundus camera with $45^\circ \times 40^\circ$ field of view. Fundus images are captured using DRS and it takes less than 30sec to capture a single image. It is fully automated device that captures central retina images without pupil dilation. These images are used by eye specialists for screening of diabetic retinopathy [9]. Benefits of digital retinography system [3], [4] are the requirement of minimum operator skill with software guided operations and easy transmission of images to network for remote views[8].

1. PROPOSED SYSTEM

This paper aims to detect the presence of abnormalities in the retina such as the structure of blood vessels and exudates for better diagnosis. The color image of the fundus is captured by DRS and it is being processed for accurate extraction of vessels and exudates [6], [7] which was recommended by doctors for their better observation. Super resolution, plane separation and contrast enhancement techniques are used for better resolution and contrast. The enhanced image is then processed using multi structure morphological techniques. Then by using filtering techniques [2], the unwanted vessels are removed for better vessel extraction. Fuzzy means clustering technique is used for the extraction of exudates. Normal left and right eye images and abnormal retinal image taken by using DRS camera are shown in Fig.1.

(a) (b) (c)

Fig.1 Retinal Image using DRS camera (a) Normal Left Eye (b) Left Eye with Abnormalities (c) Right Eye with Abnormalities

The fundamental steps involved in the proposed system for the extraction of vessels and segmentation [2], [5] of exudates are given as a process flow in Fig.2.

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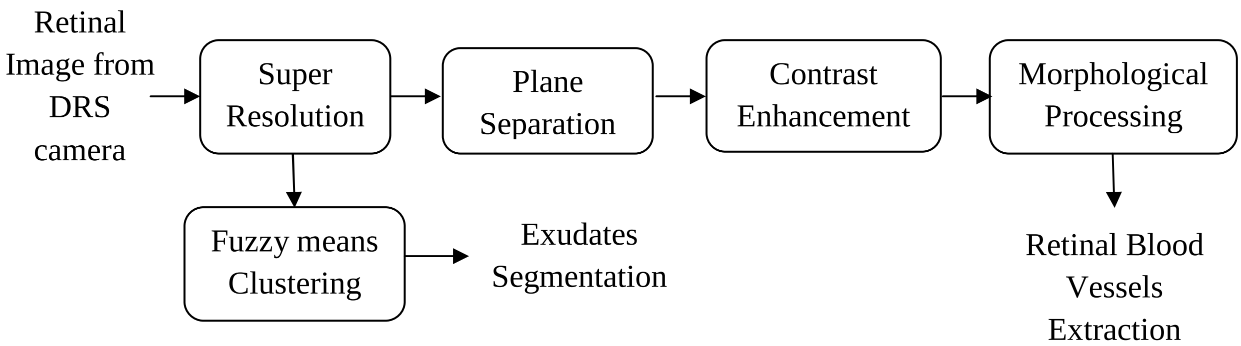


2 Process flow in Retinal Blood Vessels Extraction and Exudates Segmentation

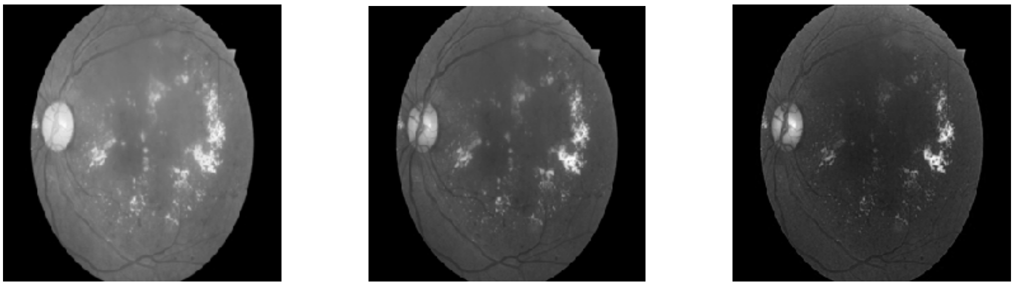
1.1 Super Resolution

Fig.3 Image after Super Resolution

The retinal images obtained from DRS camera is initially super resoluted by understanding the super pixels. This helps to identify fine details of the image with low resolution. Processing is done with and without super resolution. It is found that with super resolution the blood vessels are extracted better and is helpful in exudates segmentation. The retinal image after super resolution is shown in Fig.3.

1.2 Plane separation

Images will be of three types: binary, gray scale and color image. Here fundus image will be the color image that contains RGB plane. Each plane contains 8bits/pixel. For accurate vessel extraction, green channel will be selected as in Fig.4.



(a) (b) (c)

Fig.4 Plane Separation (a) Red Plane (b) Green plane (c) Blue Plane

1.3 Contrast enhancement using FDCT

The separated plane is then contrast enhanced by using fourier discrete curvelet transform. Curvelet transform is a new multi-scale representation most suitable for objects with curves. Using maximum co-efficient and standard deviation techniques enhancement factor is found. Enhancement factor is used for adjusting the original co-efficient and then it is matrix multiplied with the original co-efficient to form the modified co-efficient. Inverse FDCT is applied to the modified co-efficient to obtain the enhanced image shown in Fig.5.

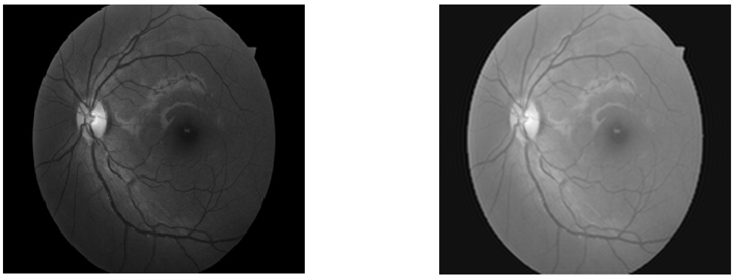


Fig.5 Contrast Enhancement (a) Before (b) After

Since the curvelet transform is well adapted to represent the images containing edges, it is a good candidate for edge enhancement. Curvelet coefficients can be modified to enhance the edges in an image, which improves the image contrast. To this end, we introduced a nonlinear function to modify the representation coefficients in such a way that details of the small amplitude are enlarged at the expense of the larger ones and perform this uniformly over all scales.

Definition of the function parameters based on some statistical features of curvelet coefficients of the input image is very beneficial to adapt the function better with every input image. Therefore, there is a need for a nonlinear function, such as ‘Y’, to multiply against the transform coefficients.

The function is defined as follows:

$$Y(x) = \begin{cases} K_1 (m / c)^p, & \text{if } |x| < ac \\ K_2 (m / |x|)^p, & \text{if } ac \le |x| < m \\ K_3, & \text{if } |x| \ge m \end{cases}$$

where ‘x’ is the curvelet coefficient,
$0 < p < 1$ determines the degree of nonlinearity,
k1, k2 and k3 are assigned weights

Each function part allows us to control the modification of coefficients with a higher severity and makes the modification more appropriate. The assigned weight helps to indicate how much the coefficients became magnified or reduced or even unchanged. The adjustment parameter ‘a’ makes it possible to determine and regulate the coefficient modification; interval Parameters ‘c’ and ‘m’ are involved in determining the coefficients modification interval as well as the amplitude of corresponding multiplying ‘Y’.

These parameters are defined according to two statistical features of coefficients. The first one is the noise standard deviation, with the aim of preventing the noise amplification, and the second one is the maximum value of coefficients in each band.

Let c=σji, where 'σji' is the noise standard deviation of coefficients being in the same direction and same scale. 'M' can be derived from maximum curvelet coefficients of the relative band MC (m=KMC), or can be determined with regard to σji (m=σji). 'K' is an additional and independent parameter from the curvelet coefficient values, and therefore, much easier for a user to set. The assigned weights and adjustment parameter are experimentally tuned based on intrinsic characteristics of the input image and the goal of work. For example, in some applications of contrast enhancement, it may be necessary to emphasize some specific part of the image. Consequently, the proposed method to enhance the retinal image consists of following steps.

1) Applying FDCT via wrapping method, a set of scales Sj is obtained, each scale consists of a set of directional bands Di containing coefficients.
2) For each directional band in each scale Dji, following steps are applied:
a) Calculation of the noise standard deviation σji;
b) Determination of the value of m.
3) Multiplication of each coefficient individually by corresponding y.
4) Reconstruction of the enhanced image using modified curvelet coefficients.

1.4 Morphological processing

Morphological operations are applied on enhanced images for smoothening the vessel part. It processes the image based on shapes using structural element. A structural element is a matrix consisting of only 0s and 1s that can have any arbitrary shape and size. There are several structural elements which are of line shape, square shape, rectangle, diamond, disk and ball shaped. 1s represent neighborhood pixel while 0s represent the background. Using multi-structure morphology elements the output image is smoothened for reducing distortion from background and increasing the edge sharpness. This is performed by image opening and closing operations with multi-structure elements. This process is known as 'Top-hat transform'. When erosion is followed by dilation then it is known as opening operation while closing operation is the dilation followed by erosion. The retinal image with extracted vessels using this methodology is shown in Fig.6.

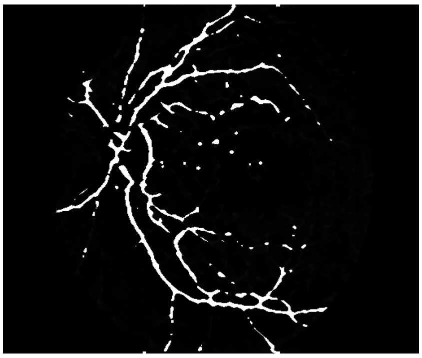
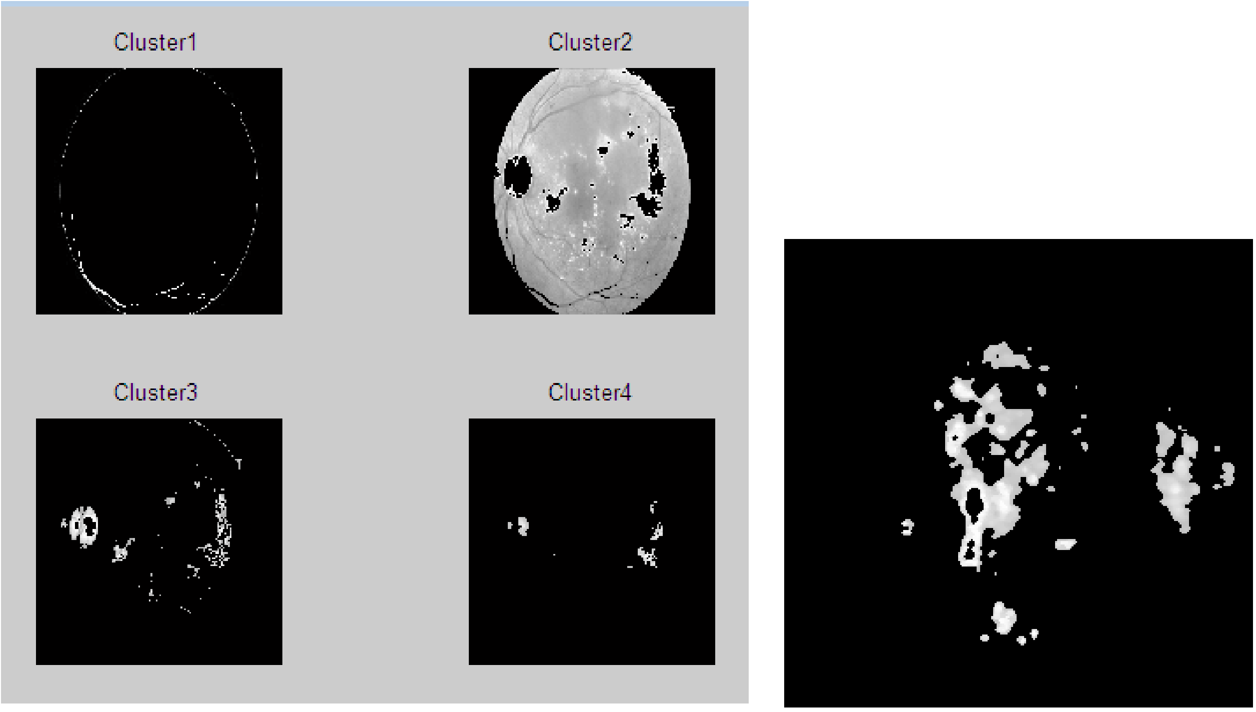


Fig.6 Retinal image with extracted vessels

1.5 Segmentation of Exudates

The yellow flecks are called exudates. They are the lipid residues of serous leakage from damaged capillaries. The commonest cause is diabetes. Other causes are retinal vein occlusion, angiomas (Von Hippel-Lindau Disease), other vascular dysplasias, and radiation-induced retinal vasculopathy [3]. Here the input image is partitioned into multiple regions using segment techniques, where the abnormal part in the fundus image will be seen in any one of the region. Using k-means clustering technique, the abnormal parts can be classified. Here k represents number of clusters. First number of clusters will be initialized as c1, c2, c3 and c4 and is shown in Fig.7.(a). The exudates detected after segmentation is shown in 7ig.7.(b).



(a) **(b)**

Fig.7 Segmentation (a) fuzzy Clusters (b) Exudates

2. PERFORMANCE PARAMETERS

Peak signal to noise ratio and Mean square error are used to find the quality of the input image in a theoretical manner, since after it is contrast enhanced. Using the parameters mean square error and peak signal to noise ratio, the quality of the image is checked. If there is more error it means that some important details of the image are altered. This helps to find the error between input image and contrast image, in order to find the quality of the image. The segmentation is checked with partition coefficient and partition entropy and is given in table.1.

Table 1. Evaluated Metrics

Parameter	Value
Mean square error	0.0777%
Peak signal to noise ratio	59.2278db
Partition coefficient	0.9550
Partition entropy	0.0403

CONCLUSION

Here the vessels and exudates are extracted successfully for better observations for ophthalmologists. Depending on the area of each feature, the severity of the disease can be classified. Then by finally knowing the severity of the disease corresponding treatment measures can be analyzed. It will surely help to reduce the risk and increase efficiency for ophthalmologists.

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