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Fovea Region Detection in Retinal Image Using Modified Watershed and Fuzzy C Means Clustering (MFCM) Algorithm

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Abstract

The main aim of this research is to provide a better detection technique for detect the fovea region from the retinal image by solving the issues that currently exist in the literature works. Hence, we have intended to propose a new detection method for the fovea region detection. Our proposed method comprised of three stages namely, blood vessels segmentation, optic disc detection and Fovea detection. Initially the retinal images will be extracted from the given input database and that each of the input images will be enhanced by applying Adaptive Histogram Equalization. Then the blood vessels will be segmented by using the Modified watershed segmentation method. In second stage, the Optic disc will be detected on the input images by using Modified region growing algorithm. Afterward, by using the segmented blood vessels and Optic disc (OD) information the fovea region will be detected by using the modified fuzzy C- Means clustering (MFCM) algorithm. Hence, the proposed technique will successfully detect the fovea region via Modified watershed and MFCM techniques. The proposed technique will be compared with the existing fovea detection methods. The proposed technique will be implemented in the working platform of MATLAB and the results will be analyzed to demonstrate the performance of the proposed fovea detection technique.

Keywords: modified fuzzy C- Means clustering (MFCM), modified watershed segmentation (MWS), Adaptive Histogram Equalization (AHE), modified region growing (MRG), Optic disc (OD), blood vessel, Fovea Region.

1. Introduction

Fovea is the most important part of the retina [10]. It is responsible for human vision. It consists of many delicate cones. If the delicate cones of the fovea are destroyed we become blind. The size of fovea zone in fundus eye image has a relation with various diseases, which may lead to blindness. Usually the zone is approximated to a circle of radius 200micron [2]. If the said radius is smaller then we can conclude that there may be some deposition at the peripheral side, and that causes some infection or disease in eye, which may tend to retinopathy or blindness. Also the radius of the fovea region may indicate the stages of retinopathy [6]. Fovea is characterized by the center of the macula [16]. The macula is the most darkest part in the form of circle [1] measuring about 4mm to 5mm in diameter [9]. Fovea is located at a distance of 2.5 times the diameter of optic disk (OD) from the macula's center [1].The retinal fundus image consists of a network of blood vessels. These vessels originate from the optic disk. The Optic Disc (OD) is a round area in the back of the eye where retinal nerve fibers collect to form the optic nerve [3]. The OD is the entry point for the major blood vessels that supply the retina. Sometimes the optic disc has the form of an ellipse because of a non-negligible angle between image plane and object plane. The size varies from patient to patient; its diameter lies between 40 and 60 pixels Based on the mathematical morphology, the center and contour of the optic disk is identified [2] Mathematical morphology is a nonlinear image-processing technique[8].

The optic disc is the entry and exit site of blood vessels and optic nerve fibers are responsible for transmitting electrical impulses from the retina to the brain[3] and its identification is important since it often works as a landmark and reference for the other features in the fundus image [19]. Blood vessels appear as networks that originate at the center of optic disk and were of progressively diminishing width. For the detection of abnormalities, since the macula has similar attributes in terms of brightness, color and contrast, and most algorithms make use of these characteristics for their detection. Macular oedema is a special case of diabetic retinopathy caused by leakage of blood vessels in the macular region [14]. If we look the fundus retinal image carefully we can see that there is no blood vessels around the macula region[17]. This feature is used to find the fovea region. Since our goal is to detect the fovea region, we need to achieve success in detecting blood vessels[3]. Once the identification of major blood vessels are carried out , an iterative algorithm is used to find out the position of OD which is in the either side of the image. Then the centroid of the blood vessels is calculated [12]. A reference line will be the vertical line through the centroid. Removal of the vessels located in the temporal side (opposite side) of OD and beyond the reference line is carried[5]. Retained vessels are skeleton zed and pruned to obtain the parabola shaped vessel. The point where the horizontal line passes through the centroid and parabola denoting the vessel intersecting each other is taken as the center of OD[13]. The OD contour is determined by using Watershed transformation with internal and external markers [4].

The fovea fundus images are most commonly used by ophthalmologists to monitor the progression for correctness and diagnosis of disease[14].They are captured using devices called ophthalmoscopes. Changes in OD shape and area may indicate disease processes, particularly glaucoma, and accurate identification of the disk boundary may be used to quantify changes. Besides, the distance between two center points of the OD for an individual is unique that can be used in security purpose [7]. Fovea size is relatively small compared to the rest of retina, but the fovea is the only area of the retina where 20/20 vision is attainable, and very important for seeing fine detail and color[18]. The challenge in fovea detection is that its size and position can vary with the chosen field of view (macula centric or optic disk centric), magnification level, non-uniform illumination; the fovea can also suffer from partial or full occlusion due to pathological factors such as lesions, scars etc [5].The retinal fundus images are broadly used in the diagnosis and treatment of various eye diseases in clinics. It is also one of the major resources for mass screening of diabetic retinopathy. If it is possible to automatically and quickly process a large number of fundus images it can help ophthalmologists by increasing the productivity and efficiency in clinical environment [15].

The overall structure of the paper is organized as follows: Section 2 reviews the related works with respect to the proposed method. In section 3 motivation of the work is given. In sections 4, a brief discussion about the proposed methodology is presented, section 5 analysis the Experimental result and section 6 concludes the paper.

2. Related Work

Soumitra Samanta *et al.* [21] have presented a simple and fast algorithm using Mathematical Morphology and geometrical features to find the fovea region. Fovea was one of the important features of a fundus retinal image. Proposed algorithm was based on the structure of the blood vessels and little bit information of the optic disk. Experiment results have been shown that the outcome of the proposed scheme was simple but efficient in extracting the fovea region. They have tested their result on a publicly available DRIVE database and got comparable results with a state of the art in that area. Moreover, it performs well on their own data set consisting of images with variation. Also the extracted macula and fovea region was robust and it may help in further diagnosis of related diseases.

Paintamilselvi *et al.* [22] have proposed the method to detect the fovea region of the eye. Two major algorithms were considered in analyzing it. First algorithm involves the isolation of blood vessels and next algorithm deals with the localization of fovea. In the second algorithm of fovea localization, sliding window technique was utilized to find the gray mixed black color fovea. The proposed approach was further enhanced to detect the diabetic retinopathy disease through feature extraction and principal component analysis method. The proposed methodology can be utilized in hospitals to detect diseases occurring on the eyes by doctors easily. Future scope of that project was to detect many eye diseases thus making mankind to be benefitted in large extent to be free from eye diseases leading to blindness with higher efficiency.

Shobhana *et al.* [23] have proposed a simple and fast algorithm by means of mathematical morphology method to detect the macular edema and the fovea region efficiently. An automatic disease detection system can significantly reduce the load of experts by limiting the referrals to those cases that require immediate consideration. The reduction in time and effort has been significant where a majority of patients screened for diseases turn out to be normal. Such a solution was a value addition to the existing infrastructure of Diabetic Retinopathy (DR) screening. It performs well on individuals own data set consisting of images with variation.

Khai Sing Chin *et al.* [24] have presented an automatic algorithm to detect the fovea center in retinal fundus images. They locate the fovea center as the region of minimum vessel density within a search region defined from anatomical priors; Priors include the approximate distance from the optic disc, expressed in multiple of the disc diameter for generality. The disc is located automatically. They tested the performance on a sample of 116 fundus images from the Tayside diabetic screening programme (TENOVUS). Algorithm result on TENOVUS images have shown good localization performance with all groups compared to manual ground truth annotations 92% estimates within 0.5 disc diameters of ground truth location with good quality, 70% with poor quality images.

Varalekshmi *et al.* [25] have proposed a method that automatically detect the fovea region in retinal fundus image in noisy conditions especially in the case of transmission. In the proposed method a special case of impulse noise was taken and fuzzy based denoising was done and the blood vessel structure was obtained using wavelet transform and finally the fovea was localized using the fuzzy c means clustering algorithm. This method has been implemented in MATLAB and tested in the publically available DRIVE database and results have been shown that method was applicable in case of low noise variances.

3. Problem Definition

Now days, diabetic retinopathy is a key reason for the blindness in elder age people. Patients who are suffering from diabetes are more likely to have eye disease but the main threat to eye sight is effect on retina. So we need to analyze the retina image to diagnosis the eye disease. In retina, Fovea is the central part of an eye is the most important part of retina. It is responsible for human vision. It consists of many delicate cones which if destroyed would lead to blindness. Many research works were developed in the area of retina image analysis by finding blood vessels segmentation, macula segmentation and fovea detection. Most likely the existing methods have utilized morphological operators, contours, filters and clustering methods in the fovea detection process. These methods have given good performance in the fovea detection process but some shortcomings are still present in those methods. In literature, a fovea detection method which is given in [21], is detects the fovea region by initially segment the blood vessels and then by using the OD (Optical Disc) geometrical information and blood vessels structure information around the macula region. But this method does not work well when the expected location of macula region is far away from the OD. Then this method will not work properly. Moreover some methods has utilized center of the input images to find the OD region. But this works are not applicable because the images from the databases are different. Another one method is given in [24], they have utilized parabola construction for the fovea detection. But this parabola construction is a complex process in the fovea region and this technique not give good performance in all databases images. Furthermore very less works are available in the fovea detection from the retina images. All the aforesaid drawbacks are solved, and then the accurate fovea detection result is obtained with higher accuracy.

4. The Proposed MFCM Based Fovea Detection Using Modified Region Growing and Modified Watershed Algorithm

Fovea is in the central part of an eye it is the most important part of retina. It is responsible for human vision. If it destroyed it would lead to blindness Fovea detection is highly important in the field of ophthalmology. For this severity analysis of blindness, we propose a fovea detection technique in our paper. In the proposed method fovea region is detected from the eye fundus image taken from the drive database. Initially the input retinal images will be extracted from the database and that each of the input images will be enhanced by using Adaptive Histogram Equalization. Then from the enhanced image the blood vessels will be segmented by using the Modified watershed segmentation method. In second stage, the Optic disc will be detected from the enhanced image by applying modified region growing algorithm. Afterward, by using the segmented blood vessels and Optic disc (OD) information the fovea region will be detected by using the modified fuzzy C- Means clustering (MFCM) algorithm. Our proposed method comprised of four stages namely,

i) **Image enhancement**
❖ Adaptive Histogram Equalization
ii) **Optic disc detection**
❖ Modified region growing
iii) **Blood vessels segmentation**
❖ Modified watershed segmentation
iv) **Fovea detection**
❖ Modified Fuzzy C Means

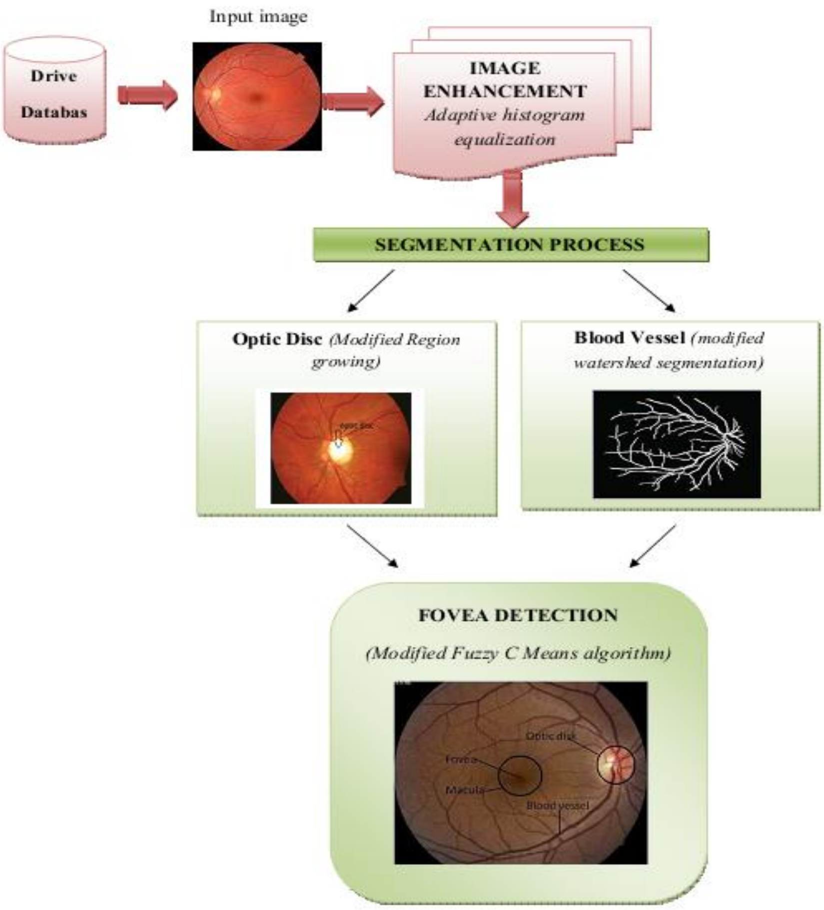


Fig: 1 Architecture of the proposed algorithm

Let $f_k : k = 1,2,\cdots N$ be a database images, (1)

Where k is the number of images from the database and f_c is the one of the image in the database f_k .

The image f_c is considered as the retinal image taken from the database f_k .The input image was enhanced by using adaptive histogram equalization and obtained the enhanced image (f_h) as a result. Then from this enhanced image (f_h) the optic disc and blood vessel were segmented. Optic disc was segmented using the modified region growing algorithm and the blood vessels are segmented using modified watershed segmentation method. These methods effectively detect the optic and blood vessel of the given input (f_h) image. Once the images are segmented using above segmentation method, the next step is to cluster the enhanced image using Modified fuzzy-c means algorithm. Using clustered image and the segmented optic disc, the macula is approximated at a distance of $2.5 \times d$ from the optic centre. The centre of the macula region is considered as the fovea. By measuring the macula centre the fovea region was detected. The detailed explanation about the proposed method is described in below sections.

4.1 Image Enhancement Using Adaptive Histogram Equalization

In order to segment the image, the contrast of the input image (f_c) has to be enhanced, which is done by performing adaptive histogram equalization (AHE). AHE is used to enhance the contrast of the image (f_c) by modifying the pixel based on its surrounding pixels. AHE is routine, locally adaptive and habitually produces superior images. Let us consider a moving window $w(w = m \times n)$ and $\text{int}(i)$ is the intensity of pixel (i, j) . Then the modification of pixel (i, j) is given as below:

$$map(\text{int}(i)) = s[t \times map_{-,-}(\text{int}(i)) + (1-t)map_{+,-}(\text{int}(i))] + [1-s][t \times map_{-,+}(\text{int}(i)) + (1-s)map_{+,+}(\text{int}(i))] \quad (2)$$

Where,

$map_{+,-}$ – *mapping of right upper* $(i_{+,-})$

$map_{+,+}$ – *mapping of right lower* $(i_{+,+})$

$map_{-,+}$ – *mapping of left upper* $(i_{-,+})$

$map_{-,-}$ – *mapping of left lower* $(i_{-,-})$

$$s = (j - j_-)/(j + \; - j_-) \quad (3)$$

$$t = (i - i_-)/(i + \; - i_-) \quad (4)$$

This modification is done for all the pixels in the entire image and finally the enhanced image (f_h) is attained. This enhanced image is given to segmentation process in order to segment the blood vessel and optic disc.

4.2 Modified Watershed Segmentation Algorithm

After the image enhancement, the blood vessel was segmented from the enhanced images (f_h). The segmentation of blood vessel is carried out by modified watershed algorithm.

4.2.1 Segmentation Using Canny Edge Detection Based Adaptive Watershed Algorithm

Step 1: The enhanced images (f_h) is initially converted from the RGB format into Gray scale format.

Step 2:.In order to detect boundaries and the edges in the image, initially we apply the canny edge detection method to the enhanced image (f_h).

4.2.1.1 Canny Edge Detection Method

This method effectively detects the edges of the given input (f_h) enhanced image.

The edges of the enhanced images are detected by using canny Edge Detection algorithm. The process of edge detection algorithm is given below in detail.

Step 1 - Smoothing:- Any noises presents in the image can be filter out by the smoothing process with the help of Gaussian filter. The Gaussian mask is slide over the image to manipulate a square of pixels at a time and which is smaller than the actual image size.

Step 2 – Finding Gradients:- From the smoothed image, the gradients are found using Sobel operator. In Sobel operator a pair of 3x3 convolution masks is utilized to find the gradients in x and y axis directions. The gradients in x-axis direction are given in the eqn. (5).

$$G_X = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \tag{5}$$

The gradients in y-ax is direction are given in the eqn. (6).

$$G_Y = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} \tag{6}$$

The magnitude of the gradient is approximated using the following eqn. (7) with the use of eqns. (5) and (6), which is also called as edge strength of the gradient.

$$|G| = |G_X| + |G_Y| \tag{7}$$

The edges are difficult to find, where they are and the directions of the edges can be found using the eqn. (8).

$$\theta = \arctan\left(\frac{|G_X|}{|G_Y|}\right) \tag{8}$$

Step 3 - Non-Maximum Suppression:- To get the sharp edges from the blurred edges, this step is performed by considering only the local maxima of the gradients. The gradient direction θ is to be rounded nearest to 45^{o}, by its corresponding 8-connected neighborhood. The magnitude of the current pixel is compared with the magnitude of the pixel in the positive and negative gradient direction. If the magnitude of the current pixel is greatest value means, then only preserve that pixel magnitude value; otherwise suppress the particular pixel magnitude value.

Step 4 - Thresholding:- The edge pixels that remains after the non-maximum suppression process are subjected to the thresholding process by choosing the thresholds in order to find the only true edges in the image. The edge pixels that are stronger than the high threshold are considered as strong edge pixels and the edge pixels that are weaker than the low threshold are suppressed. And also, the edge pixels between these two thresholds are taken as weak edge pixels.

Step 5 – Edge Tracking:- Edge pixels are divided into connected BLOB's (Binary Large OBjects) using 8-connected neighborhood. The BLOB's that have at least one of the strong edge pixels are preserved and the other BLOB's without strong edge pixels are suppressed.

Thus from the enhanced image (f_h), we obtain the edge detected image. Hence, from the optimal thresholds of intensity and orientation, the given input image gets segmented with its detected edge and the output image is represented as $(ed(f_h))$ Once the edges of the images $(ed(f_h))$ are obtained using above canny edge detection method, we need to split out various regions in the image using Watershed algorithm.

4.2.2. Watershed Algorithm

"Topography" is a way to the source of Watershed technique, which creates this technique for segmenting the images. The water from the landscape drains into which reservoir or river body is called as "catchment basin". The intensity of water will be increased, if the water is drained continuous to the catchment basin. The adjacent catchment basins are separated by the lines with maximum altitude or dams called as watershed lines in order to distinguish the water bodies in dissimilar catchments. Whereas the water is drained into the target reservoir, it is not sure that to which catchment basins it belongs. This creates the categorization of every point as moreover it belongs to catchment basins or to the watershed. Until all the maximum points are immersed the draining of water is sustained. Every pixel of an image belongs to either watershed or to catchment basin in this watershed approach which is theoretically and practically applied to the image segmentation problem. As the consequence, every pixel in the image that belongs to the catchment basins is distributed in one same label and the other pixels that are belonging to the watershed are in different labels.

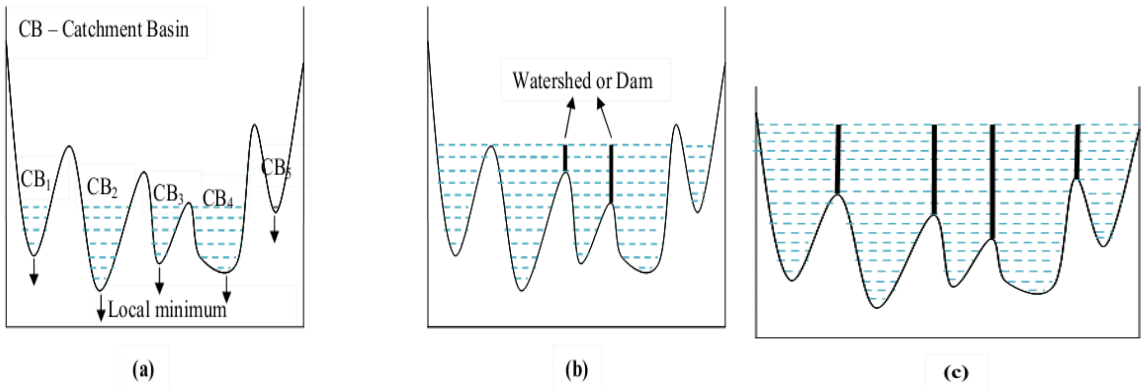


Fig. 2: Watershed concept (a) Initial stage of pouring of water (b) Construction of watersheds (c) Final stage of draining of water

Steps to segment an image using watershed segmentation

➢ The gradient magnitude for the image is calculated using the Sobel edge mask. The gradient of the image is normally low at inside of the objects and high at the border side of the object.

- Mark the dark regions of the image as the foreground objects. The foreground markers are the linked blobs of pixels in every object. The morphological techniques such as "opening-by-construction" and "closing-by-construction" that will create lat maxima inside every object. Opening-by-reconstruction is an erosion operation which execution followed by the operation of morphological reconstruction. The closing operation removes the dark spots and the stem marks from the image. These opening-by-reconstruction and closing-by-reconstruction operations are not disturbing the shapes of the objects. Then the regional maxima are computed to get well foreground markers. The objects are not marked and not segmented if the objects are most shadowed objects. After cleaning the edges of the blobs of the markers this kind of missing of marked images will be get marked.
- Calculate the background, which are not the element of the objects. The dark pixels are marked as the background of the image. Then the thresholding operation is executed. By means of "skeleton by influence zones", the background is into thinned, which effected into watershed ridge lines on the image.
- The watershed transform of the segmentation process is calculated by changing the gradient magnitude of the image. The regional minimum of this image is offered only at the foreground and background marker pixels. To carry out the segmentation based on the watershed. The object boundaries and the foreground, backgrounds are superimposed on the image by dilation.

These are the procedures for the general Watershed Algorithm for the segmentation. Morphological operations such as convolution and correlation are utilized for identifying the foreground and background**.**

Step 5.1: Use of Convolution

- Convolution is a morphological operation.
- In convolution, two arrays of different sizes are multiplied to get the third array.
- One mask or kernel is used to calculate the convolution.
- The mask is scanned over the whole image and the output pixel value is weighted sum of input array within the mask where weights are the values assigned in mask to each pixel of the window.
- Mathematically convolution can be defined as:

$$convoluton(c,h) = \sum_{k}\sum_{s} c(x-k, y-s)h(k,s) \quad (9)$$

Where c is the input image and h is the kernel

Step 5.2: Use of Correlation

- Correlation is almost similar to convolution it is computed as a weighted sum of neighboring pixels.
- Weight matrix is known as correlation kernel which is 180 degree rotation of convolution kernel.
- Mathematically, correlation is defined as:

$$correlation(c,h) = \sum_k \sum_s c(x+k, y+s) h(k,s) \tag{10}$$

Where c is input image and h is correlation kernel

The output obtained is the segmented blood vessel $bld(vsl)$ by our new Watershed Algorithm.

4.2.3 Removal of Blood Vessels

Large blood vessels $bld(vsl)$ extending from retinal may interfere with the determination of the optic disc region. In order to reduce such effect, the pixels corresponding to blood vessels were detected, and their pixel values were interpolated by those of the surrounding pixels for creating a "blood-vessel-erased" image.

4.3 Segmentation of Optic Disk Using Modified Region Growing (MRG) Method

After the retinal image enhancement, the optic disk was segmented from the enhanced retinal images (f_h). The segmentation of optic disk is carried out by modified region growing algorithm

The enhanced image (f_h) is given as the input to the segmentation process. Region growing method is a popular technique for image segmentation which involves seed point selection. In the segmentation process, the neighboring pixels are compared with the initial seed points to check based on some conditions, whether the neighboring pixels can added to the region or not. Seed point selection is important task in the segmentation. But, this normal Region Growing method selects the seed points by setting the intensity threshold, which has drawbacks of noise or variation in intensity that leads to over-segmentation or holes. Moreover, the shadings of real images may not be differentiated by this method. To overcome these difficulties, we modify the Region growing method by considering intensity and orientation thresholds from the pre-processed images to utilize those features in the selection of seed points. The process of MRG method is given in steps which are shown below:

Step 1: Calculate the gradient of the image for both x axis (f_{hx}) and (f_{hy}) y axis.

Step 2: Form the gradient vector GV by combining the gradient values using the following eqn. (2),

$$GV = \frac{1}{1 + \left(f_{hx}^{\ 2} + f_{hy}^{\ 2}\right)} \tag{11}$$

Step 3: Change the gradient vector values that are usually in radians into degrees to get the values of orientation.

Step 4: Segregate the image into grids G_i.

Step 5: Set intensity threshold $\left(int_{(t)}\right)$ and orientation threshold $\left(orient_{(t)}\right)$.

Step 6: For every grid G_i, continue the following processes in step 7 until the number of grids reached total number of grids for an image.

Step 7(a): Find the histogram h of each pixel in G_i.

Step 7(b): Determine the most frequent histogram of the G_i th grid and denote it as

$Frequent_{(h)}$.

Step 7(c): Prefer any pixel, according to $Frequent_{(h)}$ and assign that pixel as seed point which has the intensity (int_p) and Orientation $(orient_p)$.

Step 7(d): Consider the neighboring pixel having the intensity (int_n) and orientation $(orient_n)$.

Step 7(e): Find the intensity and orientation difference of those pixels p and n.

(i.e.) $D_{\text{int}} = \left\| \text{int}_p - \text{int}_n \right\|$ (12)

and $D_{orient} = \left\| orient_p - orient_n \right\|$ (13)

Step 7(f): If $D_{\text{int}} \le \text{int}_{(t)}$ && $D_{orient} \le orient_t$, then add the corresponding pixel to the region and the region is grown, else move to step 7(h).

Step 7(g): Check whether all pixels are added to the region. If true go to step 6 otherwise go to step 7(h).

Step 7(h): Re-estimate the region and find the new seed points and do the process from step 7(a).

Step 8: Stop the whole process.

Using this Modified Region Growing process, optic disks (OD) are segmented from the enhanced retinal images.

4.4 Fovea Detection Using Modified Fuzzy C- Means

Here the enhanced image (f_h) was clustered by using the Modified Fuzzy-C-means clustering method. The modified fuzzy c means algorithm is commonly used for clustering where the performance of the MFCM depends on the selection of initial cluster center or membership value. The MFCM algorithm starts with a set of initial cluster centers (or) arbitrary member ship values.

The MFCM algorithm assigns pixels to each category by using fuzzy memberships.

$$J_{\sigma m} = \sum_{i=1}^{I} \sum_{j=1}^{J} (\mu_{ij})^m \frac{\left\| x_i - z_j \right\|^2}{\sigma_i} \quad (14)$$

In Equ. (12), x_i represents the extracted image, z_j is the j th cluster centre and m is the constant value.

Where σ_i is the weighted mean distance in cluster i, and is given by

$$\sigma_i = \left\{ \frac{\sum_{j=1}^{n} u_{ij}^m \left\| x_i - z_j \right\|^2}{\sum_{j=1}^{n} u_{ij}^m} \right\}^{1/2}$$

The membership function represents the probability that a pixel belongs to a specific cluster. In the FCM algorithm, the probability is dependent on the distance between the pixel and each individual cluster center in the feature domain. The membership functions and cluster centers are updated by the equations (15) and (16).

$$u_{ij} = \frac{1}{\sum_{k=1}^{J}\left(\frac{\left\| x_i - z_j / \sigma_i \right\|}{\left\| x_i - z_k / \sigma_i \right\|}\right)^{\frac{2}{m-1}}} \quad (15)$$

The clusters centroid values is computed by using the equation (16)

$$z_j = \frac{\sum_{i=1}^{I} u_{ij}^m . x_i}{\sum_{i=1}^{I} u_{ij}^m} \quad (16)$$

Repeat the algorithm until the coefficients' change between two iterations is no more than ξ, for the given sensitivity threshold.

$$\max_{ij} \left\| U_{ij}^{(k)} - U_{ij}^{(k+1)} \right\| < \psi \quad (17)$$

In equation (14), ψ is a termination criterion between 0 and 1, whereas δ are the iteration steps. Repeat the step 12 and 13.until efficient clustering reached. Thus from the MFCM the image was clustered.

From the clustered image and the segmented optic disc the MACULA region was detected. P is the point on the horizontal line passing through the center of optic. Usually the macula region is approximated at a distance of $2.5 \times d$ from the optic centre. Select a region of interest around the located area P and Set it as mask value. A sliding window of size $k \times k$ is applied. Using sliding window techniques find the distance between each pixel. At a certain position the value will change. A chain of number of values is obtained where the number denotes the count of black pixels lying in the window. It is consider as a macula region. Then find the centroid of the macula region. The centre of the macula is fovea.

5. Results and Discussions

Our Proposed Modified Fuzzy C Means (MFCM) Based Fovea Detection technique was implemented in the working platform of MATLAB (Version 7.12) with machine configuration as follows:

Processor: Intel core i5
OS: Windows 7
CPU speed: 3.20 GHz
RAM: 4GB

Here we are segmenting the optic disc using modified region growing algorithm and blood vessel using Modified watershed segmentation method for the purpose of fovea region detection. The retinal images from the database are subjected to segmentation process.

Afterward, by using the segmented blood vessels and Optic disc (OD) information the fovea region will be detected by using the modified fuzzy C- Means clustering (MFCM) algorithm. The results will be analyzed to demonstrate the performance of the proposed technique with the existing fovea detection techniques. For our work, we use various retinal images taken from the DRIVE database.

5.1 DRIVE Database Description

The DRIVE (Digital Retinal Images for Vessel Extraction) is a publicly available database, consisting of a total of 40 color fundus photographs. The photographs were obtained from a diabetic retinopathy screening program in the Netherlands.The screening population consisted of 453 subjects between 31 and 86 years of age. Each image has been JPEG compressed, which is common practice in screening programs. Of the 40 images in the database, 7 contain pathology, namely exudates, hemorrhages and pigment epithelium changes.

The images were acquired using a Canon CR5 non-mydriatic3-CCD camera with a 45◦ field of view (FOV). Each image is captured using 8 bits per color plane at 768 ×584 pixels. The FOV of each image is circular with a diameter of approximately 540 pixels. The set of 40 images was divided into a test and training set both containing 20 images.

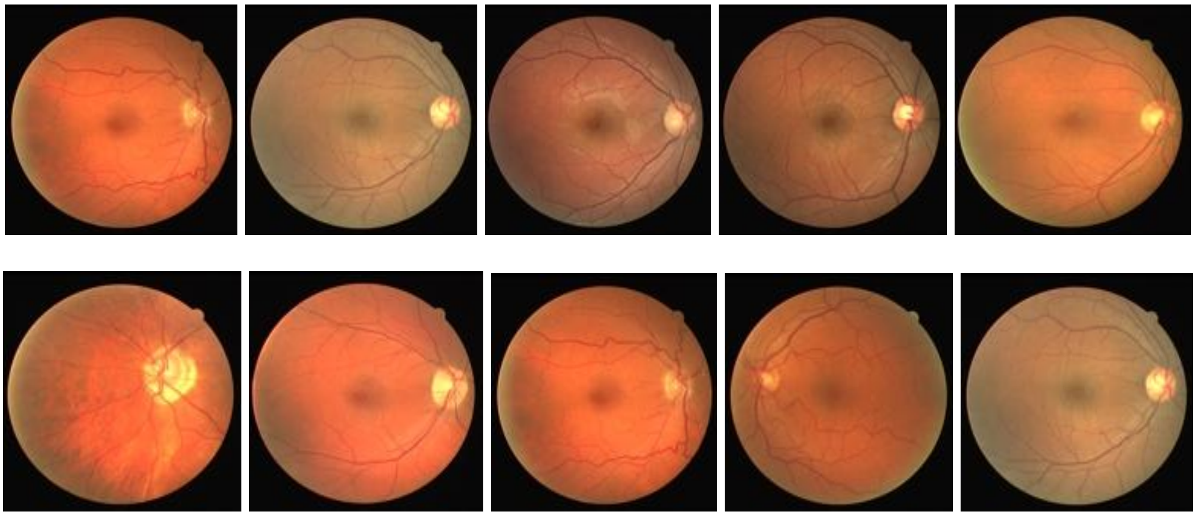


Fig 3: illustrated the Sample images from the DRIVE database

Here in fig 3. The sample database images are shown. Using modified region growing algorithm and modified watershed segmentation method, optic disc and blood vessel were segmented. Before the segmentation process the image was enhanced using adaptive histogram equalization. The enhanced mage were shown below in fig 4.

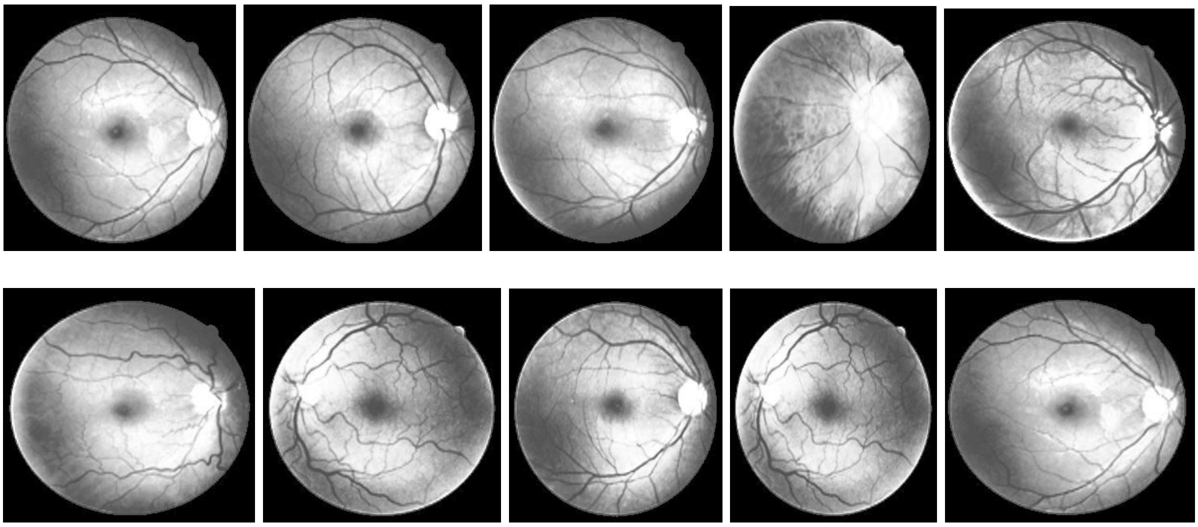
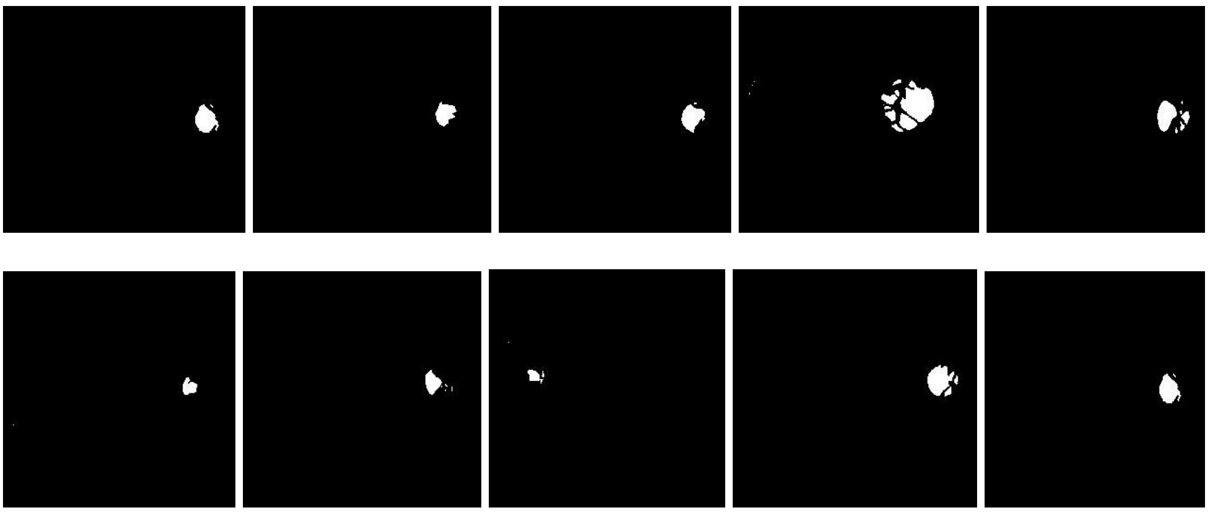
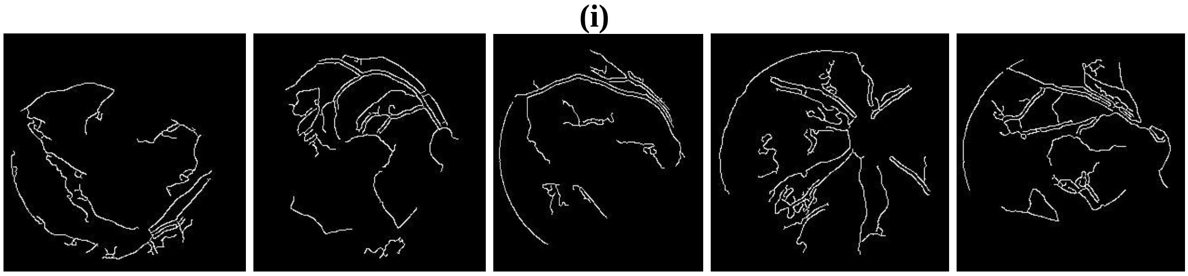


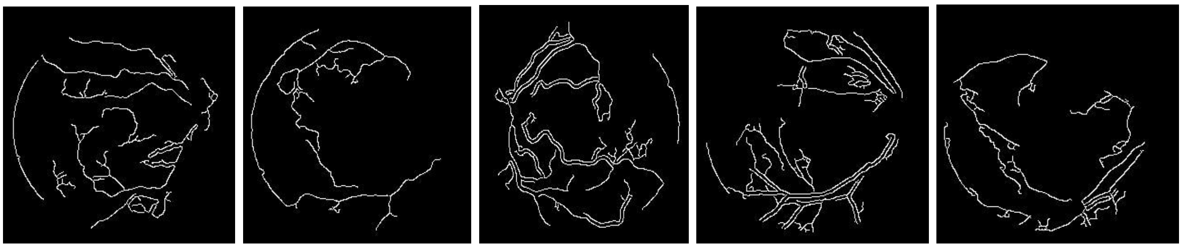
Fig 4: illustrated the enhanced image

The segmented blood vessel and optic disc were shown below in fig 5.



(i)





(ii)

Fig 5: illustrated the segmented i) optic disc and ii) blood vessel.

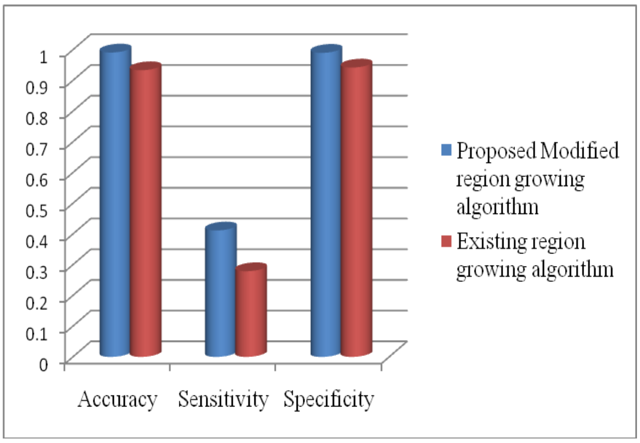
The below table I show the results of segmented optic disks, which is also illustrated in graphical representation in the fig. 6.

Table I: performance measures for the Segmentation of the optic disks for the modified region growing technique and existing region growing technique.

Measures	**Proposed Modified region growing algorithm**	**Existing region growing algorithm**
Accuracy	0.9910	0.9334
Sensitivity	0.4117	0.2790
Specificity	0.99	0.9421
FPR	0.0047	0.0578
PPV	0.6142	0.3478
NPV	0.9915	0.9899
FDR	0.074	0.65218
MCC	0.926	0.1921

Discussion

In table 1 the proposed modified region growing algorithm is compared with the Existing region growing techniques in terms of accuracy sensitivity and specificity measures. From the above table the accuracy of the proposed method is (0.9910) but the Existing technique region growing technique has offer only (0.9334) of accuracy. Similarly the sensitivity and specificity of the proposed method is (0.4117) and (0.99) but Existing technique gives (0.2790) of sensitivity and (9421) of specificity respectively. Hence from the table it has been prove that our proposed method has segmented the optic disc more accurately than the existing technique.



(i)

Fig 6: performance graph for the Segmentation of the optic disks for the modified region growing technique and existing region growing technique in terms of i) accuracy, ii) sensitivity and iii) specificity

Moreover our proposed Modified fuzzy c means algorithm is compared with the existing technique such as FCM and K Means in terms of sensitivity, specificity and accuracy measures. The clustering effectiveness of the proposed Modified fuzzy c means algorithm has been shown below in table II.

Table II: demonstrate the performance of the proposed MFCM and the existing techniques such as FCM and K-Means

Measures	Proposed Modified fuzzy c means algorithm	Existing FCM	Existing K MEANS
Accuracy	0.8995	0.6589	0.4032
Sensitivity	0.90010	0.663	0.3879
Specificity	0.901055	0.655	0.4167
FPR	0.09894	0.344	0.5832
PPV	0.8999	0.66015	0.4009
NPV	0.89904	0.657	0.4050
FDR	0.100	0.3398	0.599
MCC	0.8000	0.318	-0.194

Discussion

In table II the proposed Modified fuzzy c means algorithm is compared with the existing FCM and K Means algorithm in terms of accuracy, sensitivity and specificity measures. From the table it has been shown that the proposed Modified fuzzy c means algorithm has given of (0.8995) accuracy but the existing FCM and K Means has given only (0.6589) and (0.4032) of accuracy respectively. Similarly the sensitivity and the specificity of our proposed method are (0.90010) and (0.901055) they are higher than the existing FCM and K Means techniques. The comparison graph has been given below.

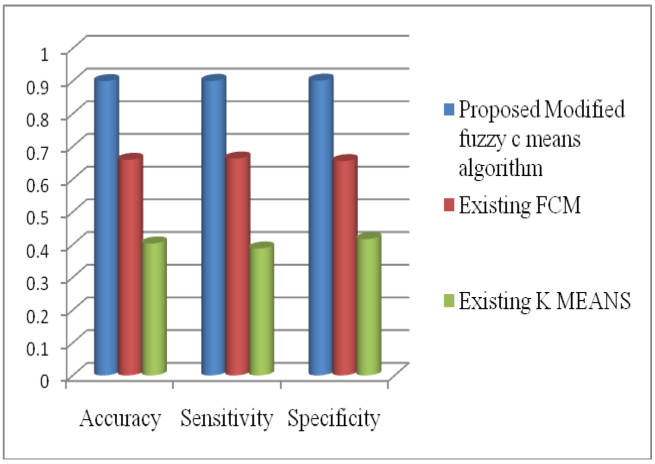


Fig. 10: demonstrate the performance of the proposed MFCM and the existing techniques such as FCM and K-Means in terms of i) accuracy, ii) sensitivity and iii) specificity

Discussion

The clustering effectiveness of the proposed Modified fuzzy c means algorithm has been compared with the existing FCM and K Means techniques and the graph has been plotted based on that evaluation metrics. The Accuracy, sensitivity and the specificity of our proposed method are higher than the existing FCM and K Means techniques. Thus from the performance metrics it has been shown that the proposed efficiently cluster the images than the existing technique.

Using clustered image and the segmented optic disc, the macula is approximated at a distance of $2.5\times d$ from the optic centre. The centre of the macula region is considered as the fovea. By measuring the macula centre the fovea region was detected. The below figure shows the obtained fovea region.

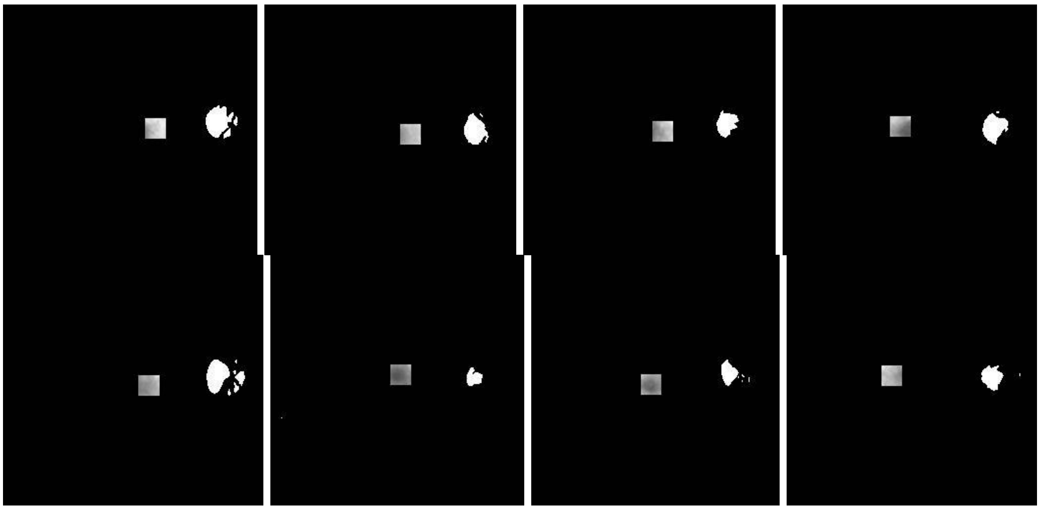


Fig 11: illustrated the fovea region.

5.2. Comparative Analysis of our proposed work with existing works

Our proposed work is compared with various existing works, in order to prove that our proposed work is better one among all the existing methods.

5.2.1. Segmentation Comparison Results

The segmentation result of our proposed work for segmenting the optic disks is obtained by using Modified region growing algorithm. This MRG segmentation result is compared with the existing techniques and the results of these three methods are given below in table III.

Methods	Proposed	Existing[21]	Existing[26]
Average Accuracy	0.9910	0.9714	0.987

Discussion

As can be seen from the table III, our proposed method has been compared with the other existing [21] and [26] methods. Our proposed method has attained high Accuracy value than other existing [21] and [26] methods for the DRIVE dataset images. The comparison graph is shown below for the proposed method and the existing average and existing method in terms of the Accuracy.

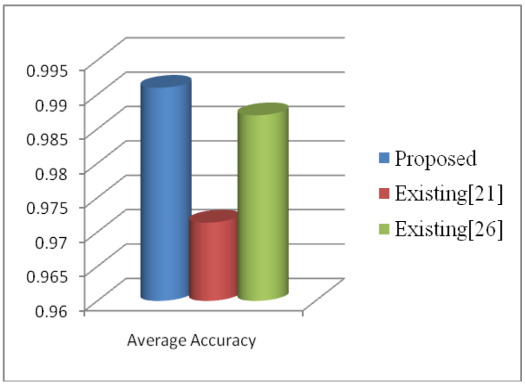


Fig 12: demonstrate the performance of the proposed technique and the existing techniques [21] and [22] in terms of accuracy

6. Conclusion

Our proposed work has provided (0.9910) of optic disks segmentation accuracy on average, and (0.8995) of clustering effectiveness using modified region growing algorithm and modified fuzzy c-means respectively. For proving that our proposed method is only better, we have compared our proposed MRG segmentation in optic disks with the existing Region Growing method and which resulted in higher values of MRG segmentation accuracy than the existing one.similarly the clustering effectiveness is compared with the existing FCM and K-Means technique and it proves the better accuracy. Moreover our proposed work is compared with the existing techniques [21] and [26]. . Hence, we can say that our proposed work outperforms other existing methods and provides effective optic segmentation and clustering results for the retinal images and thus efficiently detect the fovea region.

References

[1] Rashid Jalal Qureshi, Laszlo Kovacs, Brigitta, NagyBalazs Harangi, and Andras Hajdu, "Automatic Detection of the Fovea and Optic Disk in Digital Retinal Images by Combining Algorithms", In Proceedings of the 8th International Conference on Applied Informatics Eger, Hungary, Vol. 1, pp. 175–184, 2010.

[2] Angel Suero, Diego Marin, Manuel Gegundez Arias, and Jose Bravo, "Locating the Optic Disc in Retinal Images Using Morphological Techniques", In Proceedings of the international conference on Granada, pp. 593-600, 2013.

[3] Janardhanan, "Detection of Fovea Region in Fundus Retinal Image Using Wavelet Transform and Fuzzy C-Means Clustering", In Proceedings of 3rd IRF International Conference Chennai, pp.35-38, 2014.

[4] Veena Raj and Vidya Devi, "Retinal Image Analysis Using Fovea Detection using Unsymmetrical Trimmed Median Filter", International Journal of Engineering and Innovative Technology, Vol. 3, No. 3, pp. 263-269, 2013.

[5] JeetinderSingh, "Fundus Foveal Localization Based on Image Relative SubtractionApproach", International Journal of Computer Trends and Technology, Vol. 2, No. 3, pp. 7-9, 2012.

[6] Shobhana. and Chitrapreyanka, "A Novel Approach for Abnormality Detection of Macula and Fovea Region from Color Fundus Images", International Journal of Emerging Trends in Electrical and Electronics ,Vol. 3, No. 2, pp. 29-35, 2013.

[7] Shuvayu Goswami, Rupayan Bhattacharya and Niladri Halder, "Automatic Identification of Optic Disc in Retinal Fundus Images", International Journal of Engineering and computer Technology, Vo l. 5, No. 4, pp.54-55, 2014.

[8] Pavle Prenta, "Detection of Diabetic Retinopathy in FundusPhotographs", International Journal of Computer Trends and Technology, Vol. 3, No. 1, pp. 88-92, 2012.

[9] Ahmad Fadzil Hani, Lila Izhar, and Hanung Nugroho, "Analysis of Foveal A vascular Zone in Color Fundus Image for Grading of Diabetic Retinopathy", International Journal of Recent Trends in Engineering, Vol. 2, No. 6, pp. 101-104, 2009.

[10] Rashid Jalal Qureshi , Laszlo Kovacs, Balazs Harangi, Brigitta Nagy, Tunde Peto and Andras Hajdu, "Combining algorithms for automatic detection of Optic Disc and Maculain Fundus Images", Computer Vision and Image Understanding, Vol. 116, No.2, pp. 138–145, 2012.

[11] Revathi and Rajkumar, "In Vivo Human Retinal Imaging by Optical Coherence Tomography", International Journal of Advanced Electrical and Electronics Engineering, Vol. 2, No. 4, pp. 37-39, 2013.

[12] Faust, Oliver, Rajendra Acharya, Filippo Molinari, Subhagata Chattopadhyay, and Toshiyo Tamura. "Linear and non-linear analysis of cardiac health in diabetic subjects", Biomedical Signal Processing and Control, Vol. 7, No. 3, pp. 295-302, 2012.

[13] Madhura Jagannath Paranjpe and Kakatkar, "Review of Methods for Diabetic Retinopathy Detection and Severity Classification", International Journal of Research in Engineering and Technology, Vol. 3, No. 3, pp. 619-624, 2014.

[14] Ashok kumar, Priya and Varghese Paul, "A Novel Approach to the Detection of Macula in Human Retinal Imagery", International Journal of Signal Processing Systems, Vol. 1, No. 1, pp. 23-28, 2013.

[15] Jan Provis, Adam Dubis , Ted Maddess and Joseph Carroll, "Adaptation of the central retina for high acuity vision: Cones, the fovea and the vascular zone", Progress in Retinal and Eye Research, Vol. 35, No. 1, pp. 63- 81, 2013.

[16] Varalekshmi and Janardhanan, "Detection of Fovea Region In Fundus Retinal Image Using Wavelet Transform And Fuzzy C-Means Clustering", International Journal of Electrical, Electronics and Data Communication, Vol. 2, No. 4, pp.13-16, 2014.

[17] Fowjiya, karnan and Sivakumar, "An Automatic Detection and Assessment of Diabetic Macular Edema Along With Fovea Detection from Color Retinal Images", International Journal of Computer Trends and Technology, Vol. 4, No. 4, pp. 688-692, 2013 .

[18] Sujethra and Kavitha, "Detection and Assessment of Macular Edema", International Journal of Emerging Technology & Research, Vol. 1, No. 4, pp. 81-85, 2014.

[19] Hidetaka Noma, Katsunori Shimada and Tatsuya Mimura, "Foveal Sensitivity and Morphology in Major and Macular Branch Retinal Vein Occlusion", The Open Ophthalmology Journal, Vol. 6, No.1, pp. 104-109, 2012.

[20] Hidayat Ullah, Zahoor Jan, Rashid Jalal Qureshi and Bilal Shams, "Automated Localization of Optic Disc in Colour Fundus Images", World Applied Sciences Journal, Vol. 28, No. 11, pp. 1579-1584, 2013

[21] Soumitra Samanta, Sanjoy Kumar Saha and Bhabatosh Chanda, "A Simple and Fast Algorithm to Detect the Fovea Region in Fundus Retinal Image", In proceedings of Second International Conference on Emerging Applications of Information Technology, pp. 206-209,2011.

[22] Paintamilselvi and Shyamala, "A Novel Method to Detect The Fovea of Fundus Retinal Image", International Journal for Research and Development in Engineering, Vol. 1, No.1, pp- 21-25, 2012.

[23] Shobhana. andChitrapreyanka, "A Novel Approach for Abnormality Detection of Macula and Fovea Region from Color Fundus Images", International Journal of Emerging Trends in Electrical and Electronics , Vol. 3, No. 2, pp. 29-35, 2013.

[24] Khai Sing Chin, Emanuele Trucco, Lailing Tan and Peter Wilson, "Automatic fovea location in retinal images using anatomical priors and vessel density", Pattern Recognition Letters, Vol. 34, No.1, pp.1152–1158, 2013.

[25] Varalekshmi and Janardhanan, "Fovea Region Detection in Noisy Fundus Retinal Image Using Wavelet Transform and Clustering", International Journal of Science, Engineering and Technology Research, Vol. 3, No. 4, pp. 983-988, 2014.

[26] Mubbashar, Maryam, Anam Usman, and Usman Akram, "Automated system for macula detection in digital retinal images", Information and Communication Technologies, International Conference on. IEEE, 2011.

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