

Contrast Normalization Filtering Modules for Segmentations of Retinal Blood Vessels from Color Retinal Fundus Images

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Abstract:

Vision loss is one of the main complications of eye disease, especially diabetic retinopathy (DR), because DR is a silent disease affecting the retina of the eye and resulting in loss of vision. Manual observation of eye disease takes time and delays effective treatment, so computerized methods are used to diagnose eye disease by extracting their features such as blood vessels, optic disc, and other abnormalities. Many computerized methods are proposed but they are still lacking to obtain small vessels. To overcome this problem, we have proposed digital image enhancement methods based on image processing techniques for detection of retinal vessels. The proposed method is based on the elimination of uneven illumination using morphological tactics and Principal Component Analysis (PCA). The main propose to use the PCA to convert the Red-Green- Blue (RGB) channels into signal well contrast image. Since the PCA technique is used in the preprocessing module to get well contrast image. These initial steps are known as the preprocessing module, and our post-processing module contains the vessel coherence and the double threshold binarization method to obtain an image of the segmented vessels. Our proposed method obtained comparable results against existing methods with sensitivity: 0.78, specificity: 0.95 and precision: 0.951 on two databases namely Digital Retinal Images for Vessel Extraction (DRIVE) and Structured Analysis of The Retina (STARE). Such performance shows that our proposed method has capability to segment the retinal blood more accurately. As well as it can be tool for ophthalmologist to diagnosis the eye disease.

Keywords: Diabetic retinopathy: retinal image: optic disc: morphological tactics: Principle component analysis: double thershold..

1. Introduction

The retina is the essential part of the human eye, composed of the light-sensitive layer in the back of the eye. The purpose of the retina is to transmit light into neural signals and accommodate the brain to get explicit

knowledge. However, every part of the eye is essential for clear vision. The retina is placed beside the optic nerve, and a small darker round part is placed at the retina's central region, known as the macula. A major part of

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the macula is called the fovea that gives clear vision.[1]

Retinal eye disease is one primary disease in the list of world health organization. DR has been happened suddenly, and many abnormalities in the retina occurred due to hypertension, unhealthy diet. These factors cause many eye diseases such as Retinal detachment, Hypertensive retinopathy, Neovascular glaucoma, Retinitis pigments, and Diabetic retinopathy. These kinds of diseases may cause complications, even vision loss impairment if they remain untreated. People having diabetic between ages 20 to 74 years can get diabetic retinopathy (DR). It is estimated that people with diabetes have increased by 20 to 25 million worldwide [2].

Diabetic retinopathy is an eye-related disease that affects the geometry of eye blood vessels that may distort or blur vision and cause blindness [3]. The retinal tissue in the human eye is similar to all other parts of human body tissues. The blood received by retinal tissue via small (micro) blood vessels also depends on a continuous blood flow to maintain blood sugar levels. Microaneurysms (MAs) are caused by an abnormal sugar level in the retinal blood vessels. The DR contains various retinal abnormalities such as cotton wool spots, microaneurysms, exudates, and hemorrhages. These abnormalities cause irreversible blindness due to retinal blood vessel damage.

The fundus camera gives the color retinal images. Fundus photography captures the interior of eye images via pupil to the back of the eye is called the fundus. Fundus camera consists of low power of microscope with an onboard flash camera. Optometrists uses low power fundus photography to help get deeper knowledge of ocular health. The fundus is composed of blood vessels, optic disc, retina, macula, and fovea; these are the main retina features of the eye's interior that gives a visualization of the retinal image. An ophthalmologist analyses the obtained retinal image by manually separating the vessels from their backgrounds. A significant number of observer interventions are required in manual

segmentation, and it is a time-consuming process [4].

In the last few years, many researchers have been developing advanced techniques for the early detection of disease that can decrease the vision loss risk based on image processing techniques, especially image enhancement and segmentation. Many researchers have studied on computerized techniques for analyzing retinal blood vessel segmentation are implemented, but these studies have different issues, especially enhancement of tiny retinal blood vessels [5]. Multi-scale line detectors and morphological filters are methods based on the blood vessels segmentation. These methods are failed to address critical challenges in the analysis of retinal imaging, such as the tiny vessels detection before designing the vessel pre- detections and the removal of a noisy area of the vessels network [2]. However, a computerized system is reliable and able to create a segmented image that is highly desired to replace the previous systems of manual segmentation of blood vessel.

The automatic vessel optimization techniques require accurate segmentation of retinal blood vessels. Different algorithms are proposed for precise retinal vessel segmentation based on image processing by using filtering method. Many filters are used to remove noise pixels, but still, vessels need proper enhancement. Due to the noise issue, tiny vessels are not detected, leading to the low sensitivity of methods. We proposed pre-processing module based on adaptive wiener filtering and other basic image processing techniques. We also implemented a post-processing model based on histogram thresholding to segmented retinal blood vessels.

The paper is organized into six sections where: Section 1 is based on introduction on DR. Section 2 contain the related work, In the Section 3 explain the research methodology and elaborated each step of purposed model in detail, Section 4 based on database and measures three parameters, Section 5 contain on the result analysis and in the last section 6 based on research conclusion and future work.

2. Related Work

Many researchers have been working on different blood vessel segmentation methods in the fundus of Retinal images [6]. The blood vessels in the retinal images are multi-directionally distribute and make it is difficult to isolate accurately. The vascular network of retinal image containing veins as well as arteries. Since the blood vessels have root and branches that mimic tree. The blood vessels have a tabular shape with gradually varying orientations and widths. The low and varied contrast in the vessels makes it difficult to see the vessels accurately. Accurate segmentation of retinal blood vessels obtained by using different methods such as vessel tracking, morphological processing, filtering, machine learning, image processing techniques, and deep learning. Recently, Toufique et al. [7] developed several filter-based methods to increase the visibility of retinal blood vessels to get accurate segmentation of retinal blood vessels. Lathen et al. [8] implemented an enhanced local phase-based filter for optimal vessel improvement, and it extracts retinal blood vessels in the same vein using an intensity-based filter.

There are two automated retinal vessel segmentation methods: supervised and unsupervised retinal vessel segmentation [9]. The supervised retinal vessel segmentation method requires both user interruption and labeled data to train the vessels and non-vessel pixel classifier [10]. The classifiers are widely used in supervised retinal vessel segmentation methods, and these classifiers are Artificial Neural Networks (ANN) [11] SVM (Support Vector Machine) [12,13], GMM (Gaussian Mixture Models) [14,15], and K-Nearest Neighbors [10]. The unsupervised retinal vessel segmentation methods do not require any user interruption. The unsupervised retinal vessel segmentation methods use mathematical modeling tactics or imaging techniques to classify vessels and non-vessel pixels in an image, and they don't require any training data [9,16, 17]. The performance of supervised methods is significantly giving better result than unsupervised retinal vessel segmentation method. However, the

segmentation of supervised method initially obtaining the required data, such as expert training sampling datasets, and might be problematic with time. The most significant supervised technique disadvantage during vessel segmentation is the arduous vessels classification and the pixel value of the background. Yin et al. [18] developed a method based on the segmentation of retinal blood vessel patterns. The proposed designs define which pixels are vessels and which are non-vessels. However, this approach gives false detection on pathology images. Although a learning method has been introduced to improve their method [19,20] it has yet to be validated with retinal vessels mapping, and the tiny vessels have not been detected. Our proposed method is the un-supervised retinal segmentation method. The pre-processing steps of our methods use in the supervised segmentation methods to improve the segmentation of retinal vessels.

Among the unsupervised methods, Mendonca et al. [21] introduced a method for segmentation of retinal blood vessels, and their approach is based on morphological reconstruction tactics. An offset difference of Gaussian filter threshold (DoOG) and their methods did not pick the small vessel, although it gave several erroneous pixel detections. The techniques of the multiscale retinal vessel [22] improved in [23] by exploiting the study of the intensities of retinal images, which is related to the pixels of the vessels responding to specific pixels during the process of image acquisition. After that, multiscale data is combined using a diameter-dependent equalization factor. However, their method provided pixel detection of false vessels on some retinal images, particularly those with a center light reflex.

Toufique Ahmed et al [24] proposed an unsupervised image processing method for detecting the small vessel based on the LoG filter. This method performs better, but some tiny vessels do not detectable. Shankar, K., et al. [25] developed an automated Hyperparameter Tuning Inception-v4 (HPTI-v4) model to classify and detect DR from color retinal images.

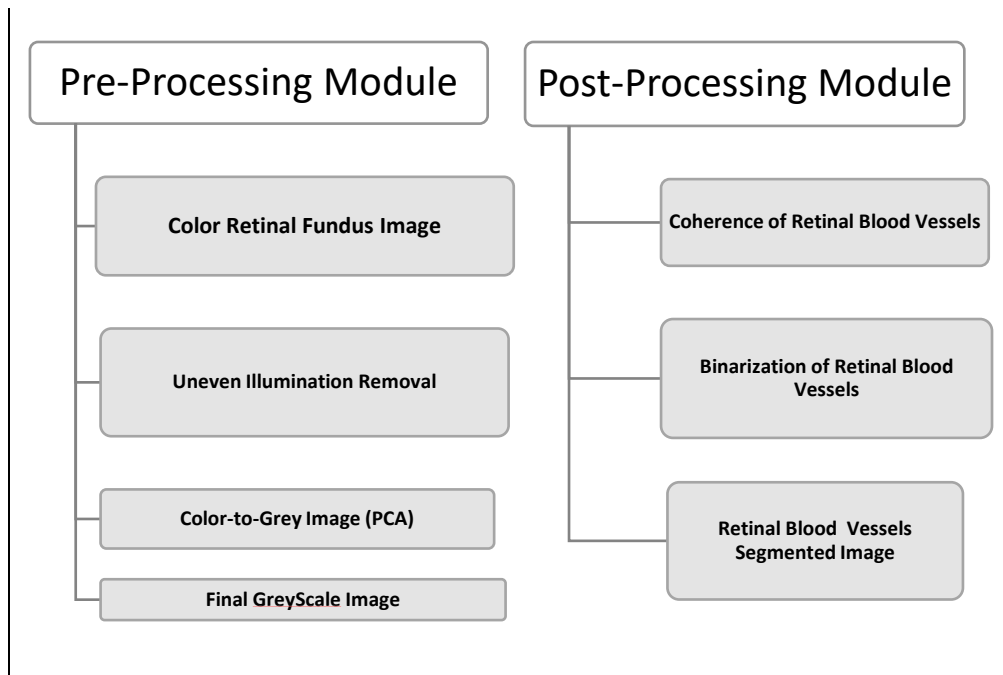


Fig. 1.Proposed Model

This model consists of various sub-processes such as initial step pre-processing, feature extraction, segmentation, and classification. Yin, Pengshuai et al. [26], implement a novel method, segment the biomedical images by deep guided network based on guided image filter for vessel segmentation, cup segmentation, and an optic disc of the retinal image. Toufique A., et al. [27] evaluated contrast normalization step for segmentation of retinal vessel.

3. Proposed Method

Segmentation of accurate blood vessels are a challenging task for the different applications of medical images specifically vessel image segmentation from color retinal fundus images. The segmented blood vessel retinal images contain several issues that make it difficult to diagnose the process of vessel segmentation due to uneven illumination, varying low contrast, and noise. Many researchers have been developing advanced

techniques for the early detection of disease that can decrease vision loss and improve the detection of tiny vessels performance. Our proposed methodology is to improve the detection of tiny vessels and retaining an acceptable level of accuracy. This method is based on main two steps: pre-processing and post-processing to obtain an image of the well-segmented vessels. The proposed model is shown in the Figure.1 while all steps are elaborated as follows. Many systems for retinal image segmentation and analysis use preprocessing as the first step. The pre-processing step in our proposed model is based on two main steps to obtain the well-segmented image, while the process is shown in figure 1.

3.1 Processing of Color retinal fundus image

Our designed retinal segmentation algorithm used retinal color fundus images as input images to give an enhanced image in pre-

processing step. Our pre-processing module used monochrome-types input images while most of the retinal image databases are monochrome in nature and the publicly available databases contain color retinal images are captured by a camera known as fundus cameras. The color retinal images contain three types of channels: red, green, and blue channels (RGB channels). Each channel carries its own information and to get the appropriate input image for the further processing as shown in the Figure 2.

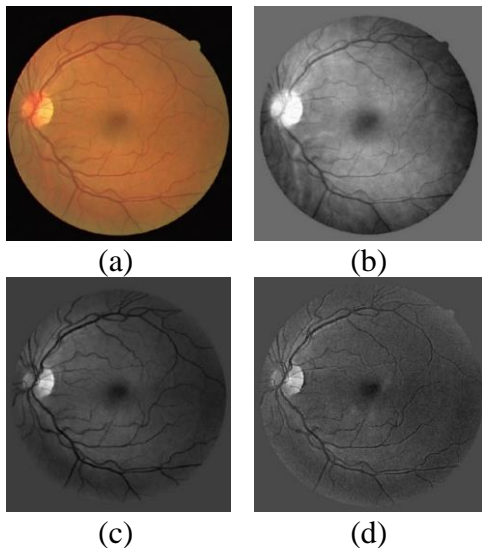


Fig. 2. Select the most suitable channel from retinal image. Where the original retinal color fundus image is shown in (a), and (b) retinal color image in RED channel, (c) retinal color image in GREEN channel, (d) retinal color image in BLUE channel.

The red channel contains both luminous information as well as noise [30] and the green channel contain least number of noisy pixel and give better vessels observation, and the blue channel contain shadow and more noise. However, green channel has a good contrast than the red and blue channels, and blood vessels are more visible in the green channel. A grayscale well-segmented output image will be obtained for further processing, and we select a grayscale image in our model for further processing because it requires less computing resources and takes less time of

processing compared to a color (RGB) image. The color images have a minimal number of advantages in the application based on image processing. Color images do process additional information, which can increase the quantity of processing data required to obtain the intended result in any segmentation method. After the selection of the grayscale image, the removal of uneven illumination is analyzed in the next step to achieve a uniform level in the retinal blood vessel against their pixels in the background.

3.2 Removal of uneven illumination

Some basic image processing techniques are used to solve the issue of uneven illumination to obtain a well uniform contrast image. The main reason for eliminating the uneven illumination is each (RGB) channel appears large variation intensity background that effect on the observation of retinal blood vessel. However, we used morphological operations, Adaptive Wiener filtering, and Lee filtering.

We tested in three ways: one based on morphological operation, second based on adaptive wiener filtering, and last on Lee filtering.

Adaptive wiener filtering: Adaptive wiener filtering is based on the least mean square method, and it is applied to the noisy image according to statistical measurement. This filter can remove the noise from the image. Their main objective is to minimize the mean square error between the filtered image and tuoriginal images. This filter modifies each pixel's values properties, and it is required to remove the high-frequency region of image and achieve an edge-preserving of an image.

A local adaptive filter is dependent on in a defined window region of image $M \times N$ are the variance and mean. This filter work based on a computation of local image variance, however, when the local variance of the image is large the little smoothing is done in a lesser amount, and if the local variance of the image is smaller the filter performs more smoothing. An adaptive filter is more selective than a linear filter of comparable type because the adaptive

filter preserves the edges as well as other high-frequency regions of the image. The pixel-wise adaptive Wiener technique is used in the adaptive Wiener filter as shown in Figure 3.

The statistics variables are taken from a local neighborhood of each pixel are used in this method. The two statistical variables such as variance and means on which wiener filter in a window size of image is based. The adaptive Wiener filter has three steps with its operation. In the first step, the mask is created by calculating the mean of the noise-contained image. This calculation uses the M x N local neighborhood of each pixel in the image and the mathematical problem for this step is represented by

$$\mu = \frac{1}{NM} \sum_{n_1=1}^N \sum_{n_2=1}^N I(n_1, n_2) \quad (1)$$

Next step, the mask is created by calculating the variance of the noise-contained image. This calculation uses the M x N local neighborhood of each pixel in the image and the mathematical problem for this step is represented by

$$\mu = \frac{1}{NM} \sum_{n_1=1}^N \sum_{n_2=1}^N I^2(n_1, n_2) - \mu^2 \quad (2)$$

In the last step, the adaptive Wiener creates a pixel-wise Wiener filter using these estimates. The mathematical problem at this step is expressed by the first step equation (1)

$$F(n_1, n_2) = \mu + \frac{\sigma^2 + v}{\sigma^2} (I(n_1, n_2)) - \mu \quad (3)$$

Where, v is noise variance. If their noise variance is not specified, however, the adaptive Wiener filter will use the average of all calculated local variances. The adaptive wiener filter output of each channel of retinal color fundus image is shown in Figure 3.

Lee filtering: The Lee filter develops the output image via integrating the central pixel intensity in a neighborhood pixel with the mask's average intensity value. This filter is better in edge preservation. This approach uses local statistics to preserve details and is based on a multiplicative speckle model.

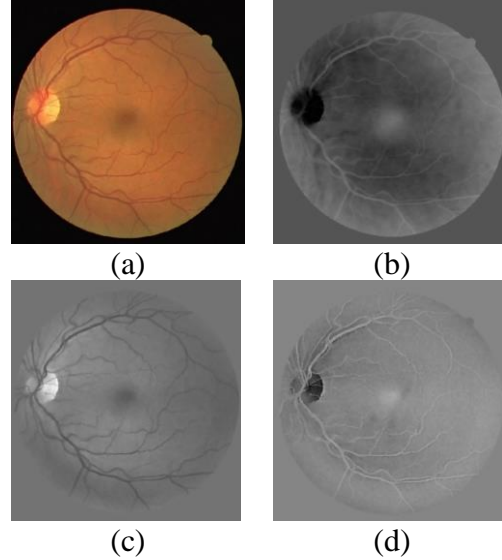


Fig. 3. Adaptive wiener filter output of each channel of retinal color fundus image. (a) input image (b) RED channel, (c) GREEN channel, (d) BLUE channel

This filter is better in edge preservation. This approach uses local statistics to preserve details and is based on a multiplicative speckle model. The lee filter works on mean and variance values [31]. If the variance area is small the smoothing operation is done but if an area of variance is high, then little smoothing is done. In contrast, this filter can preserve details in both low as well as in high contrast hence lee filter has adaptive in nature. The Lee filter mathematical method is expressed in equation (4).

$$img(m, n) = im + w \times (C_p - im) \quad (4)$$

Where, img represents the pixel value after filtering, and im means the filter window's mean intensity, C_p defines the center pixel, and w indicates the filter window's width. The filter window calculated by

$$w = \sigma^2(\sigma^2 + \rho^2) \quad (5)$$

The ρ^2 represented as additive noise variance, and σ^2 is pixel variance calculated as

$$\sigma^2 = \frac{1}{N} \sum_{j=0}^{N-1} (X_j)^2 \quad (6)$$

$$\rho^2 = \frac{1}{M} \sum_{j=0}^{M-1} (Y_j)^2 \quad (7)$$

where M is the image size and N is the window size, X_j and Y_j are each pixel value in image at j . The Lee Filter has the drawback of being unable to efficiently eliminate speckle noise near edges. The output of lee filtering is shown in Figure 4.

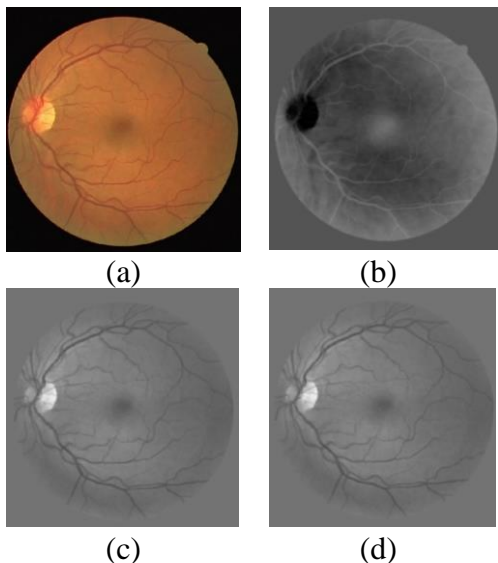


Fig. 4. Lee filter output of each channel of retinal color fundus image. (a) input image (b) RED channel, (c) GREEN channel, (d) BLUE channel.

We selected the best method by comparing the contrast level of the output image of each method and processed it for further processing. But these filtering techniques either adaptive wiener filtering and lee filtering do not give proper uniform image as shown in Figure 3 and 4. We validated the morphological operation which works successfully and achieve well contrast image.

Morphological Image Processing Operations: Morphological image processing approaches are a set of digital image processing techniques which contains mathematical morphology tactics. The main functionality of Morphological operations is used for uniform contrast variation. Morphological operations are used to eliminate noisy pixels and uneven illumination of each grayscale retinal image. It is clearly observed that each channel has uneven

illumination as well as noise as shown in the Figure 5. There are differences between background and intensities level of blood vessel, according to the analysis. The changes in these intensity levels produce an uneven illumination and noise problem since the blood vessel intensity levels are much lower than the background intensity level.

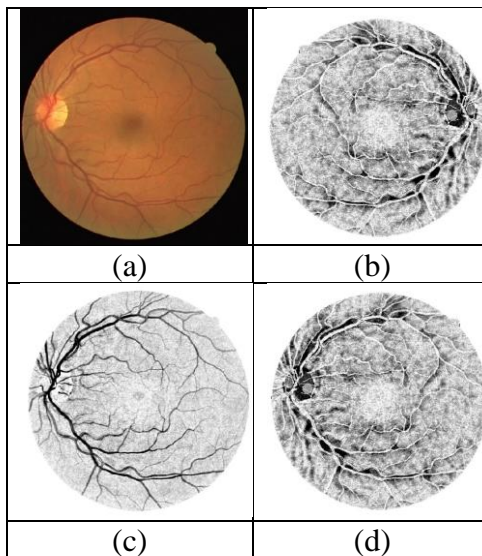


Fig. 5. Output of morphological Operation. (a) input image (b) RED channel, (c) GREEN channel, (d) BLUE channel.

There are many mathematical morphological approaches are used for image processing, the most used are closing and opening operations namely: top hat and bottom hat operation. Each RGB channel of retinal color fundus images are processed through both approaches to know how much noise affects the background of a retinal blood vessel. The top hat morphological operation is implemented as varying contrast of retinal blood vessels improved. The bottom hat morphological operation is implemented for improved the background of the image and give a sort of information to the retinal image, and it makes blood vessels more visible or enhanced while decreasing the level of noise effect on blood vessels. Finally, noise problem, as well as uneven illumination of background retinal image is eliminated

through subtracting top hat image from bottom hat image, with maintained these both issue: noise and uneven illumination, we obtained more enhanced final vessel image and observed that the vessels are more visible in Figure 5.

After comparing the output of all these filtering techniques, we can observe that more detailed of image is achieved from morphological operations as well as background contains uniformity also. As, we measured the contrasted of green channel of each vessel against their background of these techniques. The morphological techniques gave 60.12 contrast as compared to 37.28 of adaptive winner filter and 38.1 of lee filter.

3.3 Color conversion into grayscale image by PCA techniques

The grayscale images give more promising results because it used mainly for examining the details of an image. Grayscale image is crucial to maintain visual features in medical images to detect the most vital clues.

The observation of retinal blood vessels plays a vital role in observing the progression of eye illnesses in the retinal image. In this stage, the main goal is to merge the three colors (RGB) channels into a single grayscale channel image while converting RGB to grayscale show more promising outcomes. Whereas RGB background equalization of the retinal channels provides adequate representation for subsequent processing. In order to create a single grayscale image, used all three channels: red, green, and blue channels instead of the single Green channel. The principal component analysis (PCA) is used to convert a color RGB image into a grayscale image. The process is shown in Figure 6.

Our method prefers to use all three RGB channels with the use of PCA to obtain a single grayscale image by including several processing steps:

- 1) the color to grayscale conversation method is concerned with the vector color RGB images formulation ($I_{rgb} \in R^3$) through-loading three color channels: Red, Green, and Blue simultaneously. Further, a zero mean of YCbCr image ($I_{YCbCr} \in R^3$) is converted out by its RGB version to unlink such chrominance and luminance channels through transfer function $f(.)$.
- 2) The eigenvectors ($v_1 \geq v_2 \geq v_3 \in R^3$) and their corresponding eigenvalues ($\lambda_1 \geq \lambda_2 \geq \lambda_3 \in R^1$) are determined by the PCA method. The final ($I_{gray} \in R^3$) grayscale image is determined via three projections of the weighted direct blend, where weights are determined by their eigenvalue's percentage. As seen in Figure , the final output is scaled to the $[0, 1]$ range. Within three subframe projections, we achieved the final resulting grayscale image.

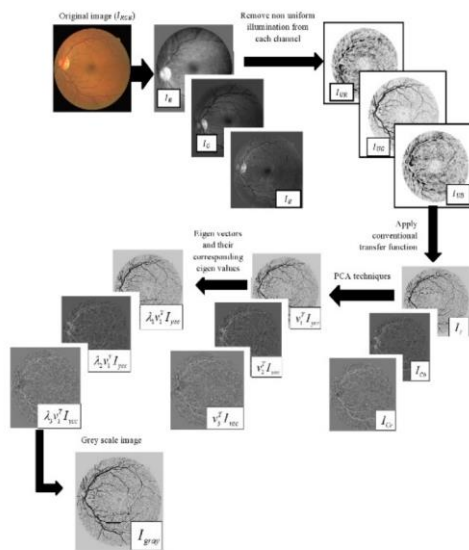


Fig. 6. PCA Based Conversion from RGB to Grayscale Image

In the first subframe, projection leads the color-to-gray transfer results because of its

significantly larger eigenvalue while other two subframe projections assist in a limited way to filling a colored image detail in the final grayscale image as shown in figure 6. The principal component Analysis (PCA) conversion is utilized to the axes rotate from color space intensity values to orthogonal axes to get an effective color conversion.

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4. Post Processing Module

The post-processing step is used to remove tiny objects from the binary image in order to binary image get well-connected vessels. This step contains the segmentation of the vessels in the retinal images. The main objective of post-processing is to analyze the effect of our pre-processing model and to assess its performance in the vessel segmentation. The post-processing step in our proposed model is based on two steps:

1. Coherence of Retinal Blood Vessels network using Contrast Normalization Filters.
2. Binarization method to achieve well segmented vessels image.

The homogenization of the background improves the overall contrast of the retinal image, it is observed that discontinuities in the vessels are present. To resolve this problem, we used a second order Gaussian derivative filter to normalize the pixels intensities between the connected vessels and give an initial coherent vessels image. But still, the small vessels do not maintain the same consistency with their background. It is therefore challenging to binarize the vessels, for getting well vessels image, we used Anisotropic diffusion filtering proposed by

[32], anisotropic diffusion filtering is used to increase the coherence of tiny vessels. The output of both coherence filters is shown in Figure 7. It clearly observed that tiny vessels are more detected in final coherence image Fig 7(b), and it leads to give more accurate segmented image in binarization process.

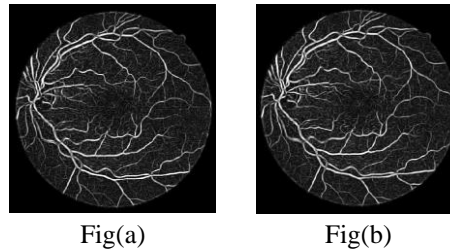


Fig. 7. Coherence of vessels. Fig (a) represents the initial coherent image, and Fig (b) represents the final coherent image.

4.1 Binary Output: Final Segmented Image

The output images of final coherent vessels still having noisy pixels, as well as some intensity variations, remain and it makes it difficult to detect tiny vessels and connect them. A better vessel segmented output image is achieved here by using the double threshold method.

This method is based on morphological reconstruction images. This reconstruction morphological image is used for the final binary output image obtained and their structure is comprised of two binary images namely: 1. mask image 2. marker image.

We assume that A and B are two binary images: A is mask image and B is marker images of same type of domain D such as $A \subset B$ i.e: $\forall p \in D, B(p) = 1 \Rightarrow A(p) = 1$ are used in reconstruction morphological image to provide binary image detail. Both marker and mask images are achieved by image histogram as shown in the Figure 8.

The Figure 8(a) shown the mask image, which is achieved by applying a mean image value based on the image histogram, and the marker image is achieved by multiplying with

standard derivation value 0.9 and subtract it by a mean image value image based on the histogram as shown in figure (b). The final binary output image as shown in Figure 8(c) and final binary image is achieved by applying morphological reconstruction operation. The mask image has more noise than the marker image and background noise is removed by multiply a standard derivation. The false pixels in the marker image background reduces, as a result, a small vessel is detected and get a better marker image by chosen 0.9 standard derivations.

We use image processing techniques to eliminate tiny objects against the binary image and obtain an accurate retinal vessel image. Because some isolated noise segments pixels are detected as false vessels because of the morphologically reconstructed process.

The small objects are removed from the reconstructed image so that the image only contains a well-connected vessel. Thus, small areas of fewer than 50 pixels are removed for this task to obtain the final binary image as shown in Figure 8(d).

4.2 Proposed algorithm

Our proposed method comprises of two main steps: 1. pre-processing 2. post processing.

The pre- processing step is based on following three stages.

1. Firstly, the retinal color fundus image proceeds as input and then convert the retinal image into RGB channels and subsequently each channel covert into greyscale images.

2. This stage is related to the removal of uneven illumination. To manage the uneven illumination from three channel by evaluated the morphological operation, lee filtering, and adaptive wiener filtering. When compared to the morphological operation, lee filter, and adaptive wiener filtering output result. The morphological operation produced well contrasted image.

3. This stage is based on machine learning techniques for obtained the well contrasted grayscale image. We convert RGB

image into grayscale image by using PCA techniques.

The post- processing steps are based on following stages.

4. The first stage of post processing related to examining the normalization of small vessel and it is crucial component in boosting the vessels sensitivity. Contrast coherent filters are used to obtain the coherent vessels image.

5. Stage 3. The third stage is based on double threshold binarization to get well segmented image.

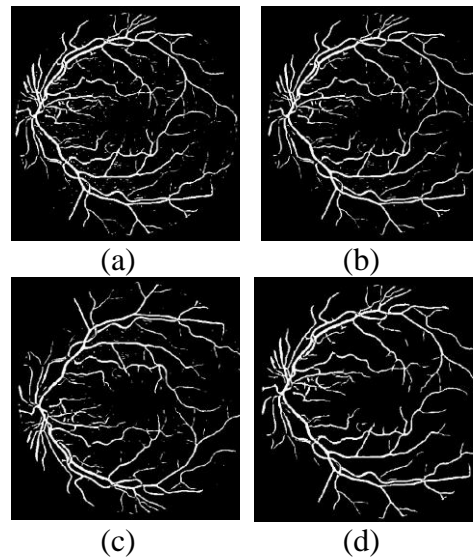


Fig. 8.

5. Database and Computing Parameters

We used two publicly available database for validating our proposed method. In this section, we introduce our database and measuring parameters also.

5.1 Database

We used the digital retinal images for vessel extraction (DRIVE) and structured analysis of the retina (STARE) database. These databases totally contained the 40 images, and each image have ground truth

image. Almost all researchers used these databases to validate their algorithm. It gives opportunity to compare the performance of our methods against existing methods.

5.2 Measuring Parameters

The most used parameters are computed, and these parameters are sensitivity, specificity, and accuracy. These three parameters are used to validate the retinal segmentation algorithm. The sensitivity and specificity is used to measure the ability of the vessels and non-vessels pixels classifications. Accuracy measured the overall performance of the algorithm. The mathematical representation of these parameters are shown below.

$$\text{Sensitivity (SE)} = \frac{TP}{TP+FN} \quad (8)$$

$$\text{Specificity (SP)} = \frac{TN}{TN+FP} \quad (9)$$

$$\text{Accuracy (AC)} = \frac{TP+TN}{TP+FP+TN+FN} \quad (10)$$

Where, TP, TN,FP and FN are true positive pixels intensity, true negative pixels intensity, false positive pixels intensity and false negative intensity.

6. Experimental Results Analysis

Our experimental result analysis section contains analysis of performance of our method on databases and comparison analysis with existing methods.

6.1 Performance on Database

The performance of our algorithm is shown in Table 1. It can be observed that our method gave accuracy of 0.948 on DRIVE and 0.941 on STARE with sensitivity of 0.80 on DRIVE and 0.79 on STARE. We analyzed the images also as shown in Figure 9. It is clearly analyzed that proposed method gives well segmented images and even tiny vessels are clearly observable and our method output is comparable with corresponding ground-truth.

TABLE I. PERFORMANCE OF OUR PROPOSED METHOD ON DATABASES

Database	SE	SP	AC
DRIVE	0.80	0.961	0.948
STARE	0.79	0.956	0.941

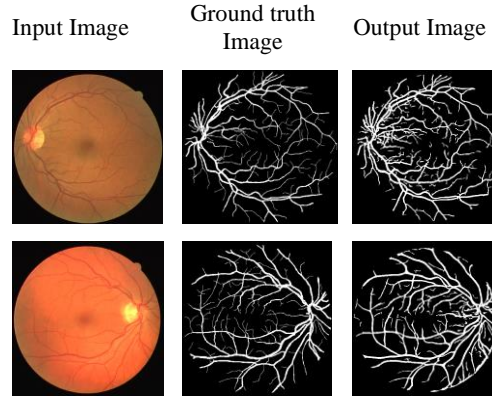


Fig. 9. Final output of proposed algorithm based on DRIVE and STARE database.

6.2 Comparison with Existing methods

The method's validation for accurate blood vessels segmentation is proven by comparing with performance of previous methods.

Many researchers use the two most extensively used publicly available databases, DRIVE and STARE, to evaluate their approaches. The Table 2 shows the comparison of performance of our proposed method with existing methods. our proposed method is based on tactics of image processing and has given higher sensitivity and accuracy (se=0.80, acc=0.948 and se=0.79, acc=0.941) on both DRIVE and STARE database than other pervious method except toufique et al [44] as well as toufique et al [45] method which have higher accuracy and sensitivity near to 96% and 81% respectively than our proposed method. It can be clearly observed that our method gave comparable performance as compared to existing methods, and it shows that our proposed method has capability to segment the retinal blood more accurately. This proposed method can be provided easy framework for ophthalmologist to more

accurately screen for retinal disorders and recommended for early treatment.

TABLE II. COMPARISON OF PROPOSED METHOD AGAINST EXISTING METHODS

Method	Year	DRIVE			STARE		
		SE	SP	AC	SE	SP	AC
Zhao et al [33]	2016	0.716	0.978	0.944	0.776	0.954	0.943
Melinscak et al [34]	2016	-	-	0.946	-	-	-
Toufique et al [35]	2016	0.714	0.968	0.946	0.709	0.965	0.942
Khan et al [36]	2016	0.737	0.967	0.951	0.736	0.971	0.951
Toufique et al [37]	2017	0.752	0.976	0.943	0.784	0.981	0.961
Toufique et al [38]	2017	0.746	0.966	0.952	0.755	0.959	0.951
Toufique et al [39]	2017	0.746	0.917	0.948	0.748	0.922	0.947
Toufique et al [40]	2018	0.752	0.976	0.953	0.786	0.982	0.967
Toufique et al [41]	2018	0.739	0.956	0.950	0.784	0.962	0.947
Khan et al [42]	2018	0.769	0.965	0.950	0.752	0.981	0.951
Toufique et al [43]	2019	0.745	0.962	0.948	0.784	0.976	0.951
Toufique et al [44]	2019	0.802	0.974	0.959	0.801	0.969	0.961
Toufique et al [45]	2021	0.812	0.971	0.963	0.809	0.969	0.958
Purposed method	2021	0.80	0.961	0.948	0.79	0.956	0.941

7. CONCLUSION

Changes in the structure of the retinal blood vessel in fundus image that can be used as a diagnostic parameter for eye diseases, especially DR. For the diagnosis of eye diseases, precise segmentation of the retinal vessels is required. Many methods have been proposed on the segmentation of retinal blood vessel but there is still need for improvement in the accurate detection of small vessels. In this research paper, we have implemented and validated the digital image contrast enhancement method based on image processing tactics and gives segmented vessels images accurately in which especially more

tiny vessels are detected. The goal was to solve the issues of varying low contrast and other challenges in analysis of color fundus images, that make it challenging to accurate Segmentation of blood vessels. The segmentation is carried out in the post-processing, but the post-processing module depends on the pre-processing module. We proposed the well preprocessing module to get a well contrasted image, and it impacted the postprocessing modulus and gave a well segmented retinal vessel image. Our proposed method is validated on public databases, namely DRIVE and STARE. The method achieved performance comparable to existing methods and it achieved higher level of

sensitivity and segmentation accuracy. Our proposed method has capability to be used to a diagnostic tool for eye diseases in the future for timely recommended treatment.

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