Retinal Vessel Extraction Using Dynamic Threshold and Enhancement Image Filter From Retina Fundus

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Received: 18/Mar/2019 Revised: 26/May/2019 Accepted: 22/Jun/2019

Abstract

Retinal blood vessels in every human being are important elements of various shapes and sizes, and retinal blood vessels can also determine various types of diseases. Therefore, retinal blood vessel extraction from the retinal fundus image is a key step in the process of recognizing the shape and size of disease patterns in the retina so that it can determine diseases of different types, but the feasibility of retinal blood vessel patterns is important for subsequent processes such as detection, identification, and classification. The previous method that focused on retinal vessel extraction has its own characteristics, especially in the pre-processing, extraction, and post-processing stages. However, there were still many characteristics in previous studies that made it insufficient to meet the needs of ophthalmologists, especially in the segmentation stage, many retinal vessels disappeared at the ends and became thicker, even assuming noise became a retinal blood vessel. Therefore, we conducted an experiment to develop retinal blood vessel segmentation in the medical world using Retina Fundus Dynamic Threshold and Image Enhancement Filter. By using the latest approach in the preprocess namely Butterworth Bandpass Filter as Enhancement Image Filter and the latest segmentation using Dynamic Threshold with a small time value for implementation with low device specification. In this paper we use the databases of DRIVE and STARE. So the proposed method for achieving the average measurement parameters from the DRIVE database is 94.77 percent accuracy and the STARE database is 87.68 percent accuracy.

Keywords: Butterworth Bandpass Filter; Dynamic Threshold; DRIVE; Retinal Blood Vessels; Segmentation; STARE.

1. Introduction

In the diagnosis of retinal disease, retinal blood vessels play an important role in determining certain diseases. Therefore retinal blood vessel extraction from the retinal fundus is a key step in the process of recognizing the shape and size of patterns of disease in the retina with its variety. Images that cover retina, blood vessels, and optic nerve are called retinal image. The retina contains important parts such as blood vessels, macula, cornea, iris, and lenses. Blood vessels have a variety of forms and different types of individuals. The structure of the vessels in the retina image is shaped from the branch line so that retinal blood vessel extraction becomes a line detection problem [1]. Therefore, in dealing with eye syndrome, blood vessels become an important medical object.

Retinal vascular extraction is the main step in detecting blindness-causing eye diseases, including retinopathy [2]. Retinal vascular extraction from digital retinal fundus images is a key step in many computerized diagnostic processes in retinal eye pathology such as diabetes retinopathy, macular degeneration, glaucoma, and occlusion of retinal artery [3]. In high-resolution retinal fundus images can help ophthalmologists diagnose disease automatically by extracting blood vessels, optical disks, and macules [4]. At present, the problem often occurs is a problem found in the image of the retina in the extraction of the blood vessels.

Previous methods of extracting retinal blood vessels have their own concentration, particularly in processing. Blood vessel treatment is characterized by color (redness), shape (curvature), gradient (limit), contrast (background image), etc. However, there are still many characteristics that make it not enough to satisfy as needed. However, there are still many characteristics that make it insufficient to satisfy as needed.

From the description above, the author has observed several existing methods for the extraction of blood vessels with the aim of adjusting medical needs. In steps, the image is changed to grayscale with a certain intensity using gamma correction, the image is enhanced by brightness using Contrast-Limited Adaptive Histogram Equalization, then the Butterworth Bandpass Filter as an image smoothing and sharpening. Then the blood vessels are segmented or extracted using Dynamic Threshold after closing morphology, Median filtering and removing small pixels to clear unwanted noise so that the final results are obtained.

2. Related Work

In this section, we review previous work with different methods on the extraction of retina blood vessels. A lot of research over the past few years has focused on methods that have their own characteristics such as J Dash [5]

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propose an approach with three phased segmentation processes where the image is processed using CLAHE in the first step. The segmentation is then performed using ISODATA method. Then, morphological cleaning is done in the third stage to reduce the noise generated during the segmentation process. However, the generated data is still not sufficiently accurate based on the Ground Truth Dataset and is stopped at the ISODATA stage which has a definite value in the cluster number if it finds a threshold value.

Dash et al [6] proposes an approach that is Unsupervised extraction of blood vessel retinal. it has three stages segmentation process is the process of pre-processes, extraction, and post-process. Unsupervised on the segmentation process using the adaptive threshold. Although it has a machine learning system in the paper, it is not explained about the unsupervised system and the pre-process that only relies on gamma correction in order to increase the segmentation parameter results.

Biran et al [2] Proposed an image enhancement filter method such as Gabor, Gauss and Frangi. The results obtained only in the form of images of blood vessels, however, still have some excessive points at the end of the vessels.

Guu et al [7] Proposed automatic retinal vessel extraction method, classified into three tracking-based and filtering-based classification categories. This method has a low level of complexity. These methods are very sensitive to noise, so that the performance is not very good. In this method, the non-vascular structure in the image of the retinal blood vessels also makes the appearance of misclassified pixels.

There are also still images in this method of small segments of blood vessels that are not visible and can not be extracted. According to Soomro et al [8] use CLAHE techniques to provide better images, but diagnostic performance in terms of blood vessel segmentation may decrease due to the loss of small vessels that will disappear.

Several processes discussed in the experiment can identify diabetes in the retina of the eye. Ben Abdallah et al [9] using a multiscale medialness method that shows that the proposed method performs well with contrast but that the retinal fundus image is so low that the green channel is considered because it has the highest contrast between the blood vessels and the background and the end of the slowly disappearing blood vessel also takes a lot of time to get the test results.

Kamble et al [10] using phase stretch transform and the method used by many includes interference after changing the transformation stage to produce a small increase in the width of retinal blood vessels in post-processing operations.

B.Khomri et al [11] using the elite-guided multi-objective artificial bee colony (EMOABC) method as the pre-process segmentation stage with the top hat and green channel, although there are still deficiencies in the focus of retinal vessels, especially for accuracy.

3. Proposed Method and Model

In this paper we are using using Dynamic Threshold and Enhancement Image Filter From Retina Fundus. For extraction of retinal fundus images using Dynamic threhold. The extracted grayscale is improved using gamma correction and CLAHE is applied to extract retinal blood vessels in low quality then a Butterworth Bandpass Filter is performed to sharpen the image as a pre-process. Along with the process, some non-pixel vessels will be removed with the help of the post-processing phase or bwareopen, median filters and morphology closing. The stages of the proposed method of blood vessel extraction are illustrated in Figure 1.

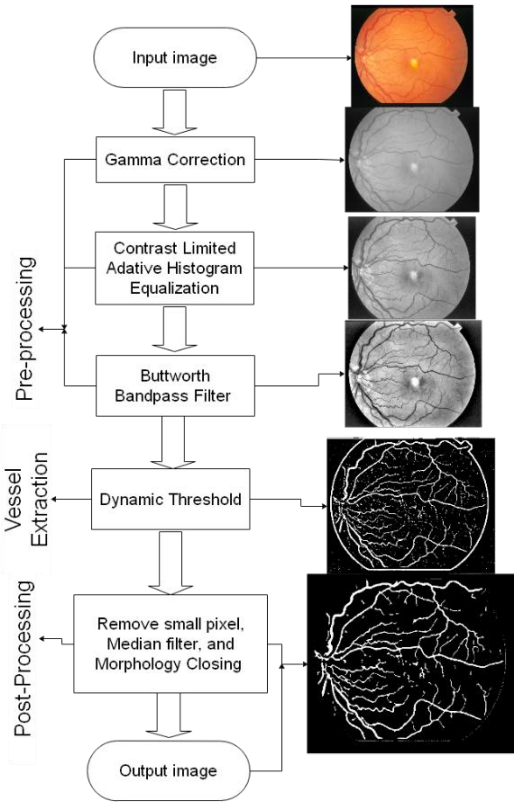


Fig. 1. Method Diagram

3.1 Pre-Process

The first step is to prepare a Retina Fundus Image as an Input Image. Fundus Retina images in the form of data originating from DRIVE and STARE database. After getting the data in the Input Image step. Then the Pre-process is done to achieve higher performance accuracy such as image enhancement, filtering, color change, etc. Several techniques are performed in pre-processing as follows:

- Gamma Correction

In the first step of preprocessing, this is Grayscale with the Gamma Correction approach to improve image brightness [12].

The formula used for gamma correction [6] [12] amirin Eq.(1) is as follows:

$$O = C\, I\gamma \qquad (1)$$

where O = output, C = constant, γ = gamma and I = input.

- Contrast-Limited Adaptive Histogram Equalization

After performing the gamma correction then using Contrast-Limited Adaptive Histogram Equalization

(CLAHE). The aim of CLAHE is to improve low contrast image quality [13][14].

CLAHE is an improved version of Adaptive Histogram Equalization (AHE) that divides images into small regions and works on individual constituencies where the contrast of each small constituency is strengthened [6].

- Butterworth Bandpass Filtering

After doing CLAHE, then filtering is Butterworth Bandpass Filtering. The Butterworth Bandpass Filter is a combination of Butterworth Low pass and Butterworth High Pass. Filtering is done to change the fundus image to be sharper by taking high and low frequency data to a certain extent.

With the formula in Eq. (2) Butterworth Low pass Filter [15][16] as follows:

$$H_{LP}(u,v) = \frac{1}{1+[\frac{D(u,v)}{D_L}]^{2n}} \quad (2)$$

With the formula in Eq. (3) Butterworth High pass Filter [15][16] as follows:

$$H_{HP}(u,v) = 1 - \frac{1}{1+[\frac{D(u,v)}{D_H}]^{2n}} \quad (3)$$

With the formula in Eq. (4) Butterworth Band pass Filter [15] as follows:

$$H_{BP}(u,v) = H_{LP}(u,v) * H_{HP}(u,v) \quad (4)$$

Where H_{LP} is Butterworth Low Pass Filter, H_{HP} is Butterworth High Pass Filter, H_{BP} is Butterworth Bandpass Pass Filter, DL is the low pass filter frequencies in Eq. (3) and DH is the frequency of the high pass filter in Eq. (4), n is the sequence of filters D (u, v) is the matrix of u and v.

3.2 Vessel Extraction

After pre-processing, the next step is to do a blood vessel extraction (vessel segmentation). In this process it consists of Dynamic Threshold and complement image as follows. Steps taken in the vessel process this extraction is the Dynamic Threshold [17]. This process converts grayscale images into binary images in the form of 0 and 1 values.

An alternative approach to finding local thresholds is to test statistically the values of the local environmental intensity of each pixel [6]. The most appropriate statistics depend on the input image. Simple and fast functions include the average local intensity distribution, the median value, or the average minimum and maximum values. With the formula [6] [18] in Eq. (5) as follows:

$$L(x,y) = \begin{cases} 1, & \text{if} I_E(x,y) > T(x,y) \\ 0, & \text{if} I_E(x,y) \leq T(x,y) \end{cases} \quad (5)$$

where L(x, y) is the result of dynamic threshold and IE(x, y) and T(x, y) are state representations for inputting an image.

3.3 Post-Process

After doing the vessel for extraction. The final step is to post-process. This process will clean up the noise. Cleaning noise using morphology closing, median filtering and bwareopening or removing small pixels from binary images and smoothing out the end of the root of blood vessels resulting from the binary or threshold image. Background cleaning is also done to focus on taking blood vessels by changing the overall black retina and the outer side or apart from the white retina, so that the unnecessary background will disappear through a reduction operation. Median Filter is a nonlinear digital filtering technique, which is often used to eliminate noise from images or signals [19]. This noise reduction is a typical post-processing step to improve the final processing results. The formula used for median filter [16] in Eq. (6) is as follows:

$$y[m,n] = \text{median}\{x[i,j]\}, (i,j) \epsilon\, \omega \quad (6)$$

Where ω represents a user-defined environment, centered around the location [m, n] in the image.

4. Results and Performance Analysis

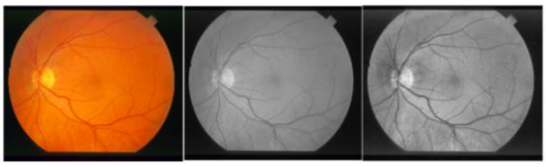
In this research we used MATLAB with the specifications of device are Celeron processor Dual core 2957U 1.4 GHz laptop, Intel HD graphics with 2 GB RAM.

The Fundus Retina used in this paper for performance of the segmentation process is verified and estimated on the publicly available are data on 20 retinal fundus images obtained from DRIVE [21] and STARE [20] databases.

The DRIVE database is one of the most used databases to focus on segmenting retinal blood vessels. The set of 40 images has been divided into a training and a test set, both containing 20 images. The DRIVE database on the segmentation process of this research using TIF format and the segmentation results using JPG format.

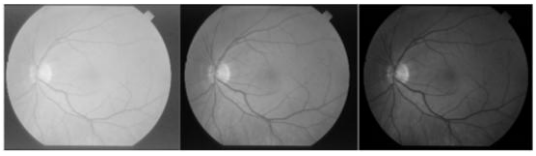
Same as the DRIVE database, STARE was funded by the U.S. National Institutes of Health. During its history, over thirty people contributed to the project, with backgrounds ranging from medicine to science to engineering. STARE is available in full 400 sets of raw images, ground truth with blood vessel segmentation, optical discs, and diagnosis codes.

The following is one image processing from the dataset Figure 2. (a). The image of the initial grayscale from the pre-process with the gamma grayscale correction can be seen in Figure 2. (b). Gamma correction is very important to present the image exactly on the monitor. Corrected images can look either bleached or too dark. The greater the gamma value for grayscale correction, the image will be fainter. In this experiment we used a gamma value of 0.9 seen in Figure 2. (b). Gamma values provide brightness variations in the image can be seen in Figure 2. (d). This variation will have a strong enough impact on the blood vessels, which will either be dimmed or disappeared and will be clearly visible if continued on the next process. So gamma correction is very important in adjusting contrast to focus on the blood vessels by getting the desired intensity so that it has a good impact on the CLAHE process. CLAHE makes the image contrast change sharper than the gamma correction process can be seen in Figure 2.(c) so that the blood vessel area is dark while other than the veins are grayish and bright.



(a) (b) (c)

Fig. 2. (a) Original Image. [22]
(b) Gamma correction
(c) CLAHE
(d) Gamma correction with Various Value Gamma (y)



y=0.2 y=1 y=2
(y)

In Figure 3. (a) is a Butterworth Bandpass filter result. Butterworth bandpass filter is a combination of low pass and high pass filter. Low-pass filter itself as smoothing from an image while high-pass itself as an increase in the sharpness of the mind. Therefore this filtering is done to change the fundus image to be sharper and smoother by taking high and low frequency data to a certain extent so that the focus on the blood vessels is more clearly visible due to differences in color with strong density. In this Butterworth Bandpass filter using $D_L = 10$ and $D_H = 5000$ and n = 500 on the order filter, this is the standard value in this study. The variation in the value of the Butterworth Bandpass filter is as follows in Figure 3. (c). The influence that is very strong when using a value that is not in accordance with the testing standard is the result that it is easy to get more noise in the Thresholding process.

Then use Dynamic Threshold which functions to make certain parts brighter while the other parts become darker or change the image to binary can be seen in Figure 3. (b). The effect depends on the Butterworth bandpass filter process when the color of the retinal blood vessels is darker so the Threshold process will be more visible to the root end, therefore Gamma correction processes, CLAHE and Butterworth bandpass filters are very important in determining the shape, size and length of blood vessels retina.

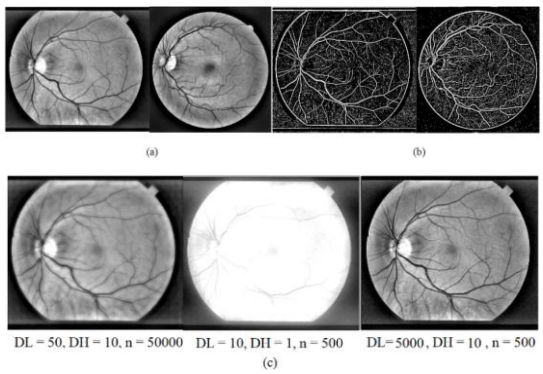


Fig 3. (a). Butterworth Bandpass filter at STARE (left) DRIVE (right). (b). Dynamic Threshold at STARE (left) DRIVE (right). (c). The variation in the value of the Butterworth bandpass filter at STARE

In the post-process it is important to make background deletions that are not needed. Focusing on the retinal vessels means removing the retinal vessels from the other side. Bwareopen image is useful for removing all connected components that are not needed from binary images or thresholds. This also has a Threshold dependency as well as the most major Gamma correction, CLAHE and Butterworth bandpass filters. Not only the role of Bwareopen, but the median filter is also very important as a smoothing of small dots so that the median filter can disappear noise by changing based on the middle pixel value. The illustration can be seen in Figure 4. (a) which is one of the final results of removing the background and connected small pixels assisted by the shape of the retina or mask to remove the background from the outside of the retina in Figure 4. (b) by doing reduction of the final result with a mask so that the final result is obtained in Figure 4. (a).

The results of image processing from DRIVE and STARE database in Table 1. In this case we will do a comparison with the ground truth DRIVE and STARE database. The measurement parameter value will be large if the retinal blood vessels approach in accordance with the dataset starting from the beginning of the retinal blood vessel to the end.

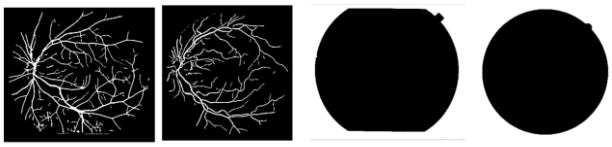
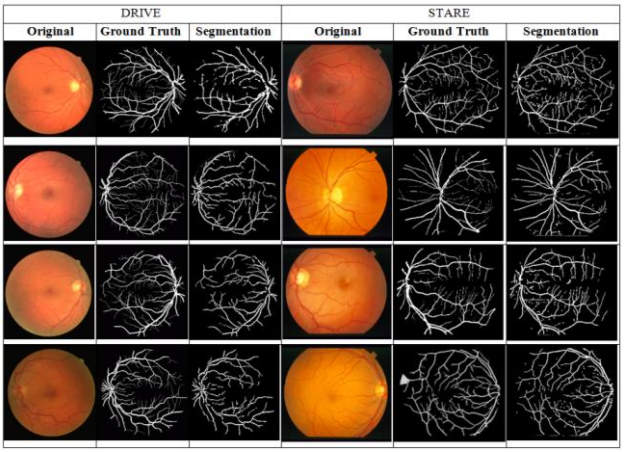


Fig. 4. (a). Morphology and Remove Background at STARE (left) DRIVE (right). (b) Retina Mask for remove background at STARE (left) DRIVE (right).

Table 1. Segmentation result from DRIVE and STARE databases



In measuring the parameters of a research performance is an important thing to do. This will illustrate how well the research is done by matching based on the retinal ground truth dataset. The parameter method used to measure data compatibility with datasets is Confusion Matrix based on binary images. Measurement Parameters can be seen in Table 2 as follows:

Table 2. Measurement Parameters

Parameters	Expresssion
Sensitivity	$\frac{TP}{TP + FN}$
Specificity	$\frac{TN}{TN + FP}$
Accuracy	$\frac{TP + TN}{TP + FN + TN + FP}$
Precision	$\frac{TP}{TP + FP}$
Recall	$\frac{TP}{TP + FN}$
F1-Measure	$2.\frac{Precision * Recall}{Precision + Recall}$

Where :

TP is True Positive, which is the amount of positive data that is matched based on the dataset correctly by the system.

TN is True Negative, which is the number of negative data that is matched based on the dataset correctly by the system.

FN is False Negative, which is the amount of negative data but is matched based on the wrong dataset by the system.

FP is False Positive, which is the amount of positive data but is matched based on the wrong dataset by the system.

Accuracy values are values that describe the correct matching of results and systems based on the dataset [23]. Specificity value describes the amount of positive category data matched based on the data set correctly divided by the total matching data based on positive data sets [23].

Sensitivity or recall can be defined as the ratio of retinal blood vessel pixels correctly classified in ground truth to the number of retinal blood vessel pixels [23].

Precision is the number of positive samples properly classified as a category divided by the total sample classified as a positive sample [24].

Based on the measurement parameters in Table 2, in this case will get the values of Accuracy, Sensitivity, Specificity Precision and F1 Measure for DRIVE and STARE databases in Table 3 as follows:

Table 3. Results Measurement parameters and Execution time from DRIVE and STARE databases

DRIVE							STARE						
File Name	Measurement parameters					Exe. Time	File Name	Measurement parameters					Exe. Time
	Acc	Se (Recall)	Sp	Prec	F1			Acc	Se (Recall)	Sp	Prec	F1	
01_test.tif	94.27	54.09	98.36	93.85	68.63	2.90 s	**im0001.ppm**	87.48	29.63	89.40	97.56	45.45	2.47 s
02_test.tif	94.39	54.82	98.41	92.84	68.94	1.93 s	**im0002.ppm**	85.48	28.07	87.64	90.96	42.90	2.43 s
03_test.tif	95.09	54.50	98.75	92.85	68.68	1.93 s	**im0003.ppm**	88.14	34.25	94.92	97.18	50.65	2.32 s
04_test.tif	94.64	54.05	98.57	87.69	66.88	1.94 s	**im0004.ppm**	89.83	28.70	90.51	86.63	43.12	2.46 s
05_test.tif	95.23	54.09	98.77	89.73	67.49	2.02 s	**im0005.ppm**	86.88	33.35	92.30	94.50	49.30	2.38 s
06_test.tif	95.31	56.42	98.06	82.70	67.08	1.92 s	**im0044.ppm**	88.73	35.39	94.66	97.96	52.00	2.64 s
07_test.tif	94.82	52.74	98.64	87.84	65.91	1.94 s	**im0077.ppm**	88.18	33.68	92.69	95.91	49.85	2.67 s
08_test.tif	94.78	54.51	98.37	84.08	66.14	2.00 s	**im0081.ppm**	86.85	29.52	91.34	95.91	45.14	2.47 s
09_test.tif	95.30	54.48	98.66	93.85	68.94	2.32 s	**im0082.ppm**	87.09	29.14	89.79	96.21	44.73	2.64 s
10_test.tif	95.02	54.33	98.61	86.95	66.87	1.84 s	**im0139.ppm**	85.85	28.66	92.21	88.47	43.29	2.45 s
11_test.tif	93.98	54.48	98.15	84.64	66.29	1.87 s	**im0162.ppm**	85.32	29.73	89.01	95.81	45.38	2.50 s
12_test.tif	94.62	52.82	98.41	87.15	65.77	1.93 s	**im0163.ppm**	87.08	31.79	89.23	93.76	47.48	2.45 s
13_test.tif	93.98	55.26	98.13	91.03	68.77	2.02 s	**im0235.ppm**	87.54	29.86	90.01	94.78	45.41	2.57 s
14_test.tif	94.80	55.63	98.22	86.04	67.57	2.02 s	**im0236.ppm**	88.22	31.13	80.02	99.39	47.41	2.61 s
15_test.tif	94.36	55.35	98.10	94.51	69.81	2.06 s	**im0239.ppm**	86.22	27.73	89.05	92.51	42.67	2.45 s
16_test.tif	94.54	56.27	98.17	91.34	69.64	1.98 s	**im0240.ppm**	87.64	24.35	95.20	95.20	38.78	2.54 s
17_test.tif	94.89	55.14	98.37	93.93	69.49	1.89 s	**im0255.ppm**	85.27	29.02	94.30	95.30	44.49	2.31 s
18_test.tif	95.10	54.12	98.50	87.04	66.74	2.05 s	**im0291.ppm**	90.56	25.73	94.95	98.65	40,81	2.41 s
19_test.tif	95.23	52.72	98.80	95.18	67.86	1.92 s	**im0319.ppm**	91.47	26.07	94.33	97.02	41,10	2.36 s
20_test.tif	95.23	53.78	98.71	90.06	67.34	2.15 s	**im0324.ppm**	89.80	24.94	93.10	92.08	39.25	2.37 s
Average	**94.77**	**54.48**	**98.43**	**89.67**	**67.74**	**2.03 s**	**Average**	**87.68**	**29.53**	**91.23**	**94.79**	**44.96**	**2.47 s**

The influence of the measurement parameter values when viewed in image processing originates from the input values at the stage carried out for example such as gamma values at the gamma correction stage, D*L*, D*H* and n values on Butterworth bandpass filters, median filters, bwareopen and threshold input values for dynamic threshold. For bwareopen and the median filter it is very influential on the value of the measurement parameters.

F1 score or F1 measure is the harmonic average of the precision and recall, where an F1 score reaches its best value at 1 (perfect precision and recall) and worst at 0 [24].

If the value of F1 measure that has been obtained and formed into a graph can be seen in Figure 5. for DRIVE and Figure 6. for STARE.

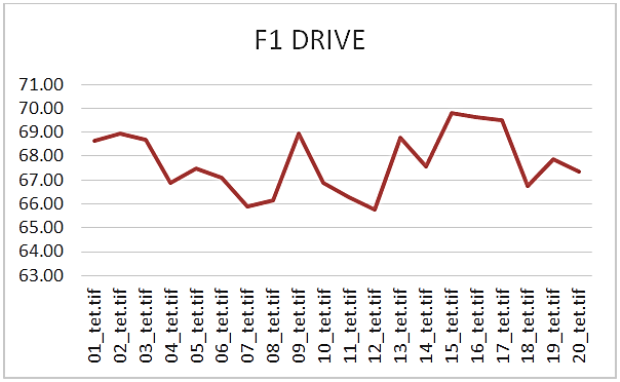


Fig. 5. F1 Measure for DRIVE

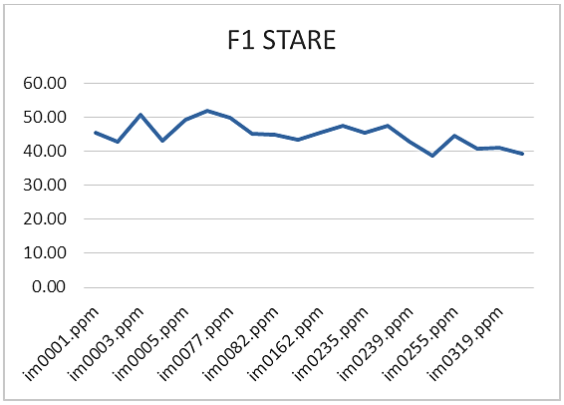


Fig. 6. F1 Measure for STARE

In Figure 5. F1 measure for DRIVE it can be seen that the highest F1 measure value is owned by the file name 15_test.tif while the lowest F1 measure is owned by the file name 12_test.tif. at Figure 6 F1 measure for STARE it can be seen that the highest value of F1 measure is possessed by file name im0044.ppm while the lowest F1 measure is owned by file name im0240.ppm. If seen from the average value of F1 measure the DRIVE value is 67.74 which is better than STARE which is 44.96.

Based on Table 3, the measurement parameter values obtained for DRIVE databases with an accuracy of 94.77%, Sensitivity 54.48%, and Specificity 98.43%. For STARE databases with an accuracy of 87.68%, Sensitivity 29.53%, and Specificity 91.23% so that in this case the values of the measurement parameters in Table 4 can be compared as follows:

Table 4. Results Segmentation comparison from DRIVE and STARE databases between previous methods.

Method		Acc	Se	Sp
DRIVE	- Extended Matched Filter Based on Second Derivative of Gaussian [1]	93.74%	-	-
	- Mathematical Morphology [3]	92%	64%	95%
	- Contrast Enhancement by Top-Hat and Bottom-Hat Transform with Optimal Strel [25]	93.77%	62.96%	98.30%
	- Green Channel, masking, and filtering (top-hat and median filters) [19]	94.02%	77.08%	99.01%
	- The Elite-guided Multi-Objective Artificial Bee Colony Algorithm [11]	94.5%	73.9%	97.4%
	- **Dynamic Threshold and Enhancement Image Filter From Retina Fundus**	**94.77%**	**54.48%**	**98.43%**
STARE	- Extended Matched Filter Based on Second Derivative of Gaussian [1]	89,31%	-	-
	- Mathematical Morphology [3]	89%	76%	89%
	- Contrast Enhancement by Top-Hat and Bottom-Hat Transform with Optimal Strel [25]	-	-	-
	- Green Channel, masking, and filtering (top-hat and median filters) [19]	-	-	-
	- The Elite-guided Multi-Objective Artificial Bee Colony Algorithm [11]	94%	73.2%	96.2%
	- **Dynamic Threshold and Enhancement Image Filter From Retina Fundus**	**87.68%**	**29.53%**	**91.23%**

Based on Table 4 the comparison of parameter values with the previous methods that the values in the proposed method are better than the previous methods, both the parameters of accuracy and specifity. Even so for the value of sensitivity is still smaller than the previous methods. But for the STARE database it still has values are smaller than previous methods on parameters measuring accuracy, sensitivity, and specificity.

Based on the execution time contained in Table 3 in which the implementation time stamp for each file so for average values obtained for DRIVE is Execution Time 2.03 seconds and for STARE is Execution Time 2.47 seconds, it can be compared with the time of implementation and the system requirements of device that used in previous methods. Here Comparison Execution Time and System requirements of device with previous methods in Table 5.

Table 5. Comparison Execution Time and System requirements of device from DRIVE and STARE databases with previous methods.

Method		Exe. Time	System
DRIVE	- Extended Matched Filter Based on Second Derivative of Gaussian [1]	2.61 s	1.65 GHZ, 2 GB RAM
	- Mathematical Morphology [3]	-	-
	- Contrast Enhancement by Top-Hat and Bottom-Hat Transform with Optimal Strel [25]	2 - 3 s	1.8 GHZ, 3 GB RAM
	- Green Channel, masking, and filtering (top-hat and median filters) [19]	1.3 s	3.7 GHZ, 8 GB RAM
	- The Elite-guided Multi-Objective Artificial Bee Colony Algorithm [11]	2.21 s	2.6 GHZ, 4 GB RAM
	- **Dynamic Threshold and Enhancement Image Filter From Retina Fundus**	**2.03 s**	**1.4 GHZ, 2 GB RAM**
STARE	- Extended Matched Filter Based on Second Derivative of Gaussian [1]	2.40 s	1.65 GHZ, 2 GB RAM
	- Mathematical Morphology [3]	-	-
	- Contrast Enhancement by Top-Hat and Bottom-Hat Transform with Optimal Strel [25]	2-3 s	1.8 GHZ, 3 GB RAM
	- Green Channel, masking, and filtering (top-hat and median filters) [19]	-	3.7 GHZ, 8 GB RAM
	- The Elite-guided Multi-Objective Artificial Bee Colony Algorithm [11]	3.14 s	2.6 GHZ, 4 GB RAM
	- **Dynamic Threshold and Enhancement Image Filter From Retina Fundus**	**2.47 s**	**1.4 GHZ, 2 GB RAM**

Based on a Table 5 at the Execution time of the proposed method has a section DRIVE database has small value compared with the previous method with the system requirements device are too low, the device Celeron 2957U processor 1.4 GHz Dual core laptop, Intel HD graphics with 2 GB of RAM also for STARE compared with previous method has enough value Execution time. Although there is a smaller time [19] but used system requirment device core i3 6th gen CPU 3.7 GHz device, 8 GB of RAM.

5. Conclusion

The extraction produced in this paper is quite good starting with the pre-process to obtain performance accuracy with image enhancement, filtering, color change, etc. and then optimized post-process. Retinal image processing experiments available for data set blood vessel extraction from the DRIVE and STARE database using accuracy, sensitivity, and specificity parameters. Thus the proposed method achieves average value of measurement parameters from DRIVE database is accuracy of 94.77 percent, sensitivity of 54.48 percent, specificity of 98.71 percent, and execution time of 2.03 seconds, and STARE database is accuracy of 87.68 percent, sensitivity of 29.53 percent, specificity of 91.23 percent, and execution time of 2.47 seconds. For DRIVE database, the comparison of parameter values with previous methods that the values in the proposed method are better than the previous methods, both the accuracy and specificity parameters. Even though the sensitivity value is still smaller than previous methods, and the STARE database still has values smaller than previous methods for parameters measuring accuracy, sensitivity, and specificity. When viewed in image processing, the influence of the measurement parameter values originates from the input values at the stage, such as gamma values at the gamma correction stage, DL, DH and n values on Butterworth bandpass filters, median filters, bwareopen and dynamic threshold input values. The value of the measurement parameters is very influential for bwareopen and the median filter. However, this method still has no match between the results of processing with the ground truth or the causes of reference such as noise and the root roots of lost or increased blood vessels.

Acknowledgement

This paper is partly supported by Rector of University of Sriwijaya. The author would like to thank United States Agency for International Development (USAID) for the training and mentoring support in writing this article, through the Sustainable Higher Education Research Alliance (SHERA) Program for Universitas Indonesia's Scientific Modelling, Application, Research and Training for City-centred Innovation and Technology (SMART CITY) Project.

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