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Performance Evaluation of Retinal Vessel Segmentation Using a Combination of Filters

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Abstract— **Image Segmentation is the procedure that breaks down any image into different parts. This is required in order to attain the essential characteristics from the image. Segmentation finds its applications in different fields of satellite imagery, weather forecasting, traffic controlling etc. But it is mainly used in the medical field to diagnose different kinds of diseases suffered by different people. Though manual segmentation provides with good results but automated analysis of retinal images is more promising as it reduces time and effort required by the experts. Diabetic Retinopathy is such a disorder of an eye which can be mostly seen in a person suffering from diabetes. If this disease is not recognized earlier the person may suffer from complete blindness. Although various techniques have been proposed to detect the blood vessels and diagnose the disorders but the main issue of noise has not been considered greatly. In this paper, a hybrid combination of two filters is proposed which provides us with better results over the existing methods even in the case when the colored retina image is more hampered by noise. The proposed method is tested on DRIVE database.**

Keywords— ***Image Segmentation, Diabetic Retinopathy, Automated Segmentation, Gabor Filter, Switching Median Filter.***

I. INTRODUCTION

The Segmentation of an image can be regarded as a simple process in which any two-dimensional image is broken down into various parts. It helps in making the image more defining and illustrating the facts which are earlier not predictable. The retina is the light sensitive coating in the back of one's eye which directs the images to your brain. In the middle of that nerve structure could be the macula. It offers the sharp, key perspective to be required for examining, operating and viewing great details. The retinal blood vessels are the main part of retina as they supply blood to the retina and also broadcast signals to the brain from retina.

Retinal Vessel Segmentation is such a process that assists in recognition of several eye disorders. Appropriate and complete segmentation is generally needed for correct examination of the vessels. The ophthalmologists mainly use two types of methods to examine the retina. One is the use of a small movable instrument known as opthalmoscope and the other method involves the use of retinal images recorded with a fundus camera. The digital fundus cameras are able to examine a large population of people without larger expansion of the pupil [1]. So it plays an important part in detecting the various disorders present in an eye which can damage the retina to a great extent. The different types of diseases that affect the retina are diabetic retinopathy, hypertension, stroke, age related macular degeneration etc.

Diabetic Retinopathy is the illness of an eye happened by complexity of diabetes that triggers various abnormalities in the retina. This disorder is classified into two stages. One is the proliferative stage in which exudates are called hard exudates. And the other is the non- proliferative stage in which exudates are known as soft exudates. In order to diagnose the diabetes related disorders it is required to detect the exudates. These exudates look as a bright yellow-white spots on the sharp boundaries [2]. Diabetic Retinopathy mostly occurs when the blood glucose level in a person's body increases to such an extent that the blood vessels swell up. In most cases, a fluid is leaked into the macula region which is mainly responsible for the clear vision. And in some cases, new blood vessels form on the sides of the retina. So it is required to diagnose and cure this disease at the early stage itself. Otherwise, it will affect the retina so much that a person might loss his complete vision [1].

Manual Segmentation is one of the oldest techniques to examine the retina of people to detect for the presence of any eye related disease. But this method needs an expert person to carry out the whole procedure which usually involves extended time and requiring more effort to examine it. In such a case, computer aided tools enable automated segmentation to take place requiring less effort and less time. The ophthalmologist may discover the illness by analyzing the segmented vessels with assistance from the development of an additional amount of vessels on retina surface, and also from their form and size [3]. This is the main reason which makes automatic segmentation to be preferred more over manual segmentation. Automated Segmentation is appealing but it is usually susceptible to noise, image quality and other different modifications within the images. Moreover, the retinal images provide two general systems, the arteries and veins. The vessels mix and overlap with some volume, particularly close to the optic disk thereby effecting the computerized segmentation of the image. These are the main factors which make the retinal vessel segmentation still a great challenge [4].

As retinal vessel segmentation is very necessary to provide timely treatment to the people suffering from various eye disorders. Therefore different segmentation methods have been provided from time to time in order to

help the people to provide cure from certain diseases at their start itself. Along with it, it will also help the clinical experts as they can record the details, images of retina, and other required information of their patients. And as the no. of patients who are suffering from various eye disorders is increasing rapidly so manual segmentation will not be helpful.

II. PROPOSED METHOD

This work mainly focuses on the recognition and segmenting of different retinal images. Though different segmentation methods have been proposed till now but there is still some scope of improvement. Noise is any unwanted signal that often gets added to the images when an image is being acquired or transmitted. So keeping this in mind a combination of two filters is used. One is the Gabor Filter and the other is the Switching Median Filter.

A. Gabor Filter

A Gabor Filter [5] is an application of linear filter which is called after the name of Dennis Gabor. This filter is typically ideal for finding the edges. It is mainly useful for function extraction and texture analysis. The evaluation of an image with this filter is regarded as being an opinion in the individual visible system. The impulse effect of Gabor filter is described with a sinusoidal plane improved with a Gaussian function.

Gabor Filter is seen as a specific kind of bandpass filter that enables a particular band of wavelengths to go through it and rejects all other bands of frequencies. This filter has a real and unreal element presenting the orthogonal directions.

Gabor Filter has its applications in almost every field whether it may be medical images, fingerprint recognition, recognizing roads in the analysis of satellite images and so on. These types of filters with various wavelengths and orientations might be useful for obtaining different characteristics from images.

Original Image **Filtered Image**

B. Switching Median Filter

A Switching Median Filter [6-7] is a classification of non-linear filter which is mainly used to remove the impulse noise present in an image. This filter identifies whether the pixels are corrupted or uncorrupted. The Switching Median Filter works in two steps i.e. Noise Detection and Noise Removal.

Noise Detection Stage is the one in which the pixels are checked for if they are corrupted with noise or not. And in the noise removal stage the value of the corrupted pixels is changed with the value of the neighbouring pixels. And those pixels which are not affected by noise are left unchanged. These filters rise above the other median filters in the way that no changing is employed in them if the pixels are not corrupted. But in other median filters, every pixel whether it is corrupted or not its value is changed with the median value of its nearby pixel. This main advantage of this filter enables us to use switching median filter over other available filters.

C. Working

The proposed method involves the working as follows:

Step 1: Take the input image which is a colored image of retina.

Step 2: Now implement the switching median filter on the input image attained in step 1. This filter is a very well known filter to remove the impulse noise present in the colored images.

Step 3: After the de-noised image is attained from step 2 then we decompose the colored image into RGB components.

Step 4: Then in this step the green colour component of the image is taken further as it shows more number of vessels and that too more clearly.

Step 5: After taking the green component, Gabor Filter is implemented on it to extract the features.

Step 6: Finally, we get a segmented retina image.

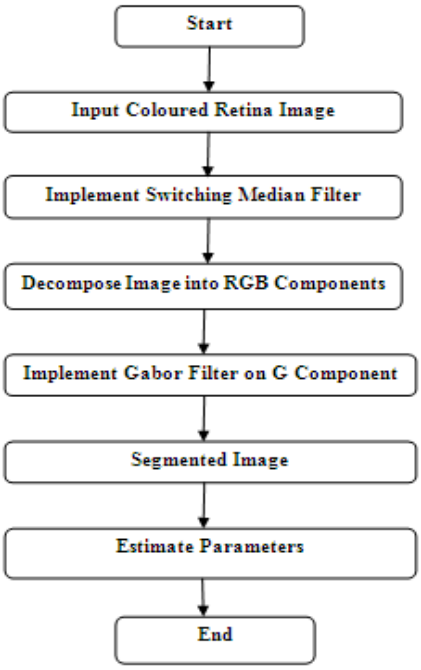


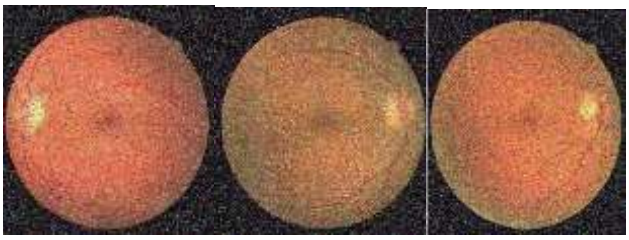
Figure 1.Flowchart for Proposed Algorithm

III. RESULTS AND DISCUSSIONS

The efficiency of the proposed method is predicted by taking a data set of images from DRIVE database. The implementation is done using image processing toolbox in MATLAB.

The existing and the proposed technique both were tested on a dataset of 10 images each which were taken from the DRIVE database which is a publically available database [10].

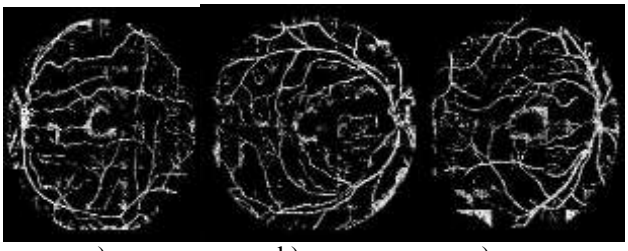
The figure 2 below shows three input images of retina with the addition of noise. The noise present in the image usually degrades the quality of an image.



a) b) c)

Figure 2 a) Right Eye b) Left Eye c) Left Eye

The figure 3 below shows the output results of the existing method which is afflicted with noise. These images are achieved by applying Gabor Filter on the input image which is noisy.



a) b) c)

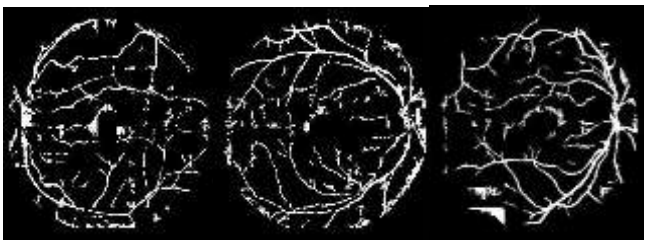
Figure 3.Segmented Noisy Images

The figure 4 which is shown below is the result which is achieved when switching median filter is applied on the input noisy image. This filter works by removing the noise present in the image and providing us with a noise free image.

a) b) c)

Figure 4.Filtered Images

The figure 5 shown below is the final stage of our proposed work in which the segmented results are shown. In the last step of our proposed work, Gabor filter is applied after applying the switching median filter. The results clearly shows that the proposed work outperforms other existing methods.



a) b) c)

Figure 5.Output Images

IV. PERFORMANCE EVALUATION

In this part, an analysis has been provided between the existing technique and the proposed work on the basis of comparison between the three known parameters. The comparative analysis will ensure that the proposed method works better than the existing one.

A. True Positive Rate (TPR)

It is one of the quality metrics which is very well known in the field of digital image processing. The table 1 given below shows the values of the existing method and the proposed method.

TPR = TP/ TP + FN

TABLE 1 True Positive Rate

Image No.	Existing Technique	Proposed Technique
Image 1	72.3054	73.3120
Image 2	73.9617	75.6391
Image 3	74.6788	75.1268
Image 4	72.5385	73.6604
Image 5	67.4689	67.9438
Image 6	68.6624	69.8232
Image 7	66.8069	67.8968
Image 8	68.4495	69.8972
Image 9	70.8660	71.9956
Image 10	68.7444	70.4497

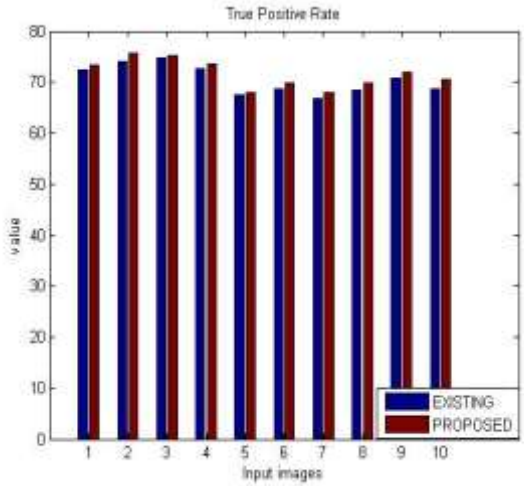


Figure 6 Graph for TPR

In the above figure 6 it shows a plot between the existing technique shown in blue colour and the proposed technique shown in red colour. It clearly states that the proposed work shows good results as it shows increasing values for various images for TPR.

B. True Negative Rate (TNR)

The table 2 given below shows the values for both existing as well as proposed method. The values for TNR should be increasing for each image for the proposed method, so it is clear from the comparison table that values for existing method are less and for proposed method are more.

TNR = TN/ TN + FP

TABLE 2 True Negative Rate

Image No.	Existing Value	Proposed Value
Image 1	0.7479	0.7581
Image 2	0.7606	0.7765
Image 3	0.7661	0.7719
Image 4	0.7474	0.7590
Image 5	0.7070	0.7131
Image 6	0.7149	0.7267
Image 7	0.7026	0.7132
Image 8	0.7150	0.7287
Image 9	0.7350	0.7460
Image 10	0.7176	0.7337

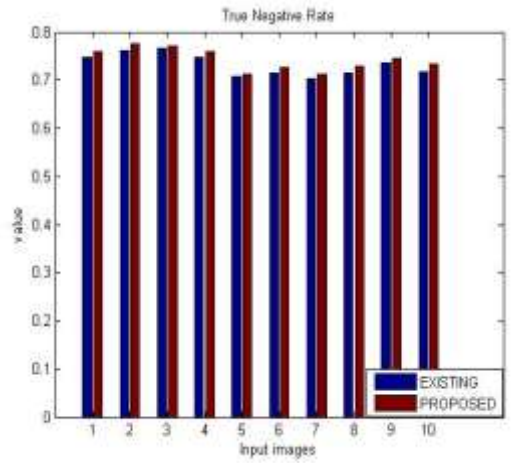


Figure 7 Graph for TNR

The above shown figure 7 shows a comparison in the form of graph in which existing values are shown in blue colour and the values for proposed method are shown in red

colour. As it is clear from the plot that the proposed method shows improved results.

C. F-Measure (FM)

The values of f-measure are given below in the comparison table 3. This metric computes some average of information retrieval precision and recall metrics. A higher value of f-measure value indicates that the classification quality is more.

FM = 2*Precision*Recall / Precision + Recall

Here, Recall specifies the sensitivity and Precision represents the ratio of correct positive observations.

TABLE 3 F-Measure

Image No.	Existing Value	Proposed Value
Image 1	96.6363	96.8502
Image 2	96.3032	96.6594
Image 3	96.0683	96.2906
Image 4	95.4370	95.7181
Image 5	95.6145	95.6308
Image 6	94.9935	95.1593
Image 7	96.2100	96.2995
Image 8	95.8817	96.0664
Image 9	96.0413	96.2396
Image 10	95.9452	96.1766

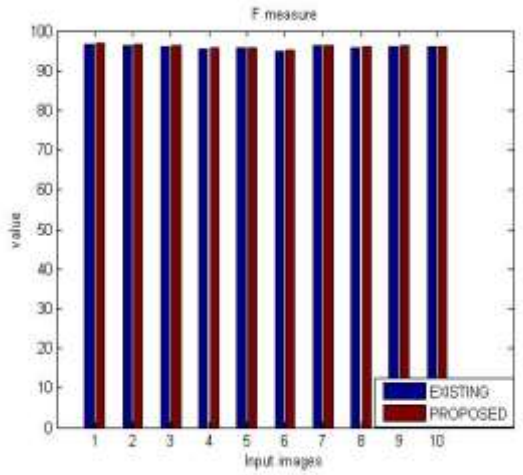


Figure 8 Graph for F-Measure

Figure 8 above shows the analysis of f-measure of different images by showing the values of existing method shown in blue colour and the proposed method shown in red colour. The above graph states clearly that the proposed work shows better results than the existing work.

III. CONCLUSION

The Automated Segmentation of blood vessels present in retina is very necessary to predict the different disorders of an eye. So it becomes very important that this segmentation should be carried out with great care. In this paper, a hybrid combination of Switching Median Filter and Gabor Filter is implemented. This combination segments the blood vessels even when the image is highly affected and degraded with noise. In this paper, a comparison between the existing technique which involves the implementation of only Gabor Filter and the proposed method which involves the hybrid combination of two filters is made. The results are evaluated on the basis of three quality parameters which involve true positive rate, true negative rate and f-measure. The results clearly states that the proposed method outperforms the existing method and is more effective.

Though this hybrid combination of Gabor Filter with Switching Median Filter gives improved results but in future this combination can be applied on a different dataset of images. This paper shows the performance analysis by taking the DRIVE database but this proposed work can be tested on different databases of STARE and CHASE to be worked in future.

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