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An Improved Approach to Segment Retinal Vessels Using a Combination of Filters

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Abstract : Segmentation is a method of dividing a given image into numerous sectors. Its objective is to categorize image into various regions in such a way that every potential object in the image gets individual sector. Instinctive recognition of diabetic retinopathy wounds, like exudates can provide an opportunity to mainly identify certain diseases. Recently, several methods of fundus extraction techniques were proposed which can extract the blood vessels in fundus images in a more promising manner. Although Gabor filter bank has shown significant results over the available techniques, but it is poor in its speed. Also it is not so efficient for multiple kind of noises at the same time.

Keywords : Image Segmentation, Diabetic Retinopathy, Gabor Filter, Switching Median Filter.

1. INTRODUCTION

Image Segmentation is a process in which we divide the image into its multiple segments thus making the image more readable, easier to understand and easier to analyze [1]. This segmentation process can be applied on different types of images but when it is applied on the retina image, it is referred to as retinal vessel segmentation. The segmentation of blood vessels present in the retina can be used by different opthalomologist to diagnose the disorders that a person might be suffering from such as diabetic retinopathy, age related macular degeneration, hypertension etc [2].

Diabetic Retinopathy is such a disease that is mostly seen in the patients suffering from diabetes. In this, it affects the retina of the patient severely. If this disease is not diagnosed in its early stages then the person might suffer from complete blindness. Therefore it is very necessary to detect the presence of any disease before it becomes too late to cure it [3].

As we know that the blood vessels present in the retina play a major role in the medical diagnosis of many diseases. So it becomes very necessary that this segmentation should be done properly and very accurately. Earlier manual segmentation of these blood vessels was done by different clinical experts. But this was found to be a very lengthy and time consuming process [4]. And also the problems arisen due to the intra and inter observer variability. So the need arises to perform this detection by making use of computer assisted tools which helps in screening the large population in a comparatively less time and reduces the workload of physical examination. And also this automatic diagnosis procedure saves time to a great extent and provides the opthalomologist with a platform where they can manage, analyze and store the retinal images of the patients for future reference.

Various methods have been developed to segment the blood vessels of the retina image. But mainly these methods are classified into two categories *i.e*. Supervised methods and Unsupervised methods. Supervised methods are such which make use of knowledge which is available before and also provide good results for segmentation. But their main problem lies in the fact that they depend on the ground truth that is acquired from the fundus images which are segmented physically and labeled by one or more experts. This involves using of neural networks,

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Bayesian classifier, K-nearest neighbour classification for classifying whether the pixels of image belong to vessel class or non-vessel class. On the other hand, unsupervised methods are those which do not use this prior knowledge. This category involves the use of matched filter responses, morphology based techniques and local adaptive thresholding based methods [5]

2. FILTERS

The process of filtering is a basic process which is applied to almost all the images in image processing in order to attain a noise free image so that the quality of the image is not decreased. The selection of filter is done on the basis of the job executed by the filter and the conduct and kind of data. Filters are accustomed to eliminate noise from the binary images thus by conserving the essential details of the image. The filters can be mainly categorized into two types:

2.1. Linear Filters

Linear Filters are the one which are used to eliminate certain kind of noises from an image. These types of filters have a tendency to blur the edges and can also damage the various other characteristics of an image. Its main types include mean filters.

(*a*) Mean Filters are those filters which are generally based on the idea of changing the value of each pixel in an image with the average value of its neighbours including itself. Therefore such filters also called average filters or box filters. The main benefit of using such filters is that they are easy to implement but these filters are not able to conserve all the essential details of the image i.e. some information might be lost during processing [6].

(*b*) A Gabor filter is a form of linear filter which is generally used for detecting edges. This filter is used for feature extraction and texture analysis. When a Gabor filtering is applied on any image, it gives the highest results at the ends and with points where by the texture improvements are seen [7].

2.2. Non-Linear Filters

These are the order statistics filters which are used to overcome the shortcomings of linear filters. These filters are able to preserve the important features and details of an image while removing noise from the image. It mainly includes median filter.

(*a*) Median Filter is a type of a non linear filter in which we do not change the value of pixel with the average value of neighbouring pixels but instead median value is used.

(*b*) A Switching Median Filter is a type of non linear filter which is mainly used to reduce the unnecessary changing of the pixels which are not affected by noise. This filter normally works in a two stage process. In the first stage, it detects the noise present in the image and in the second stage it removes that noise from the image [8].

3. PROPOSED METHODOOGY

Step 1 : Start the algorithm.

Step 2 : Firstly take any retina image as the input image.

Step 3 : Then apply Switching Median Filter to the input retina image. This filter is used to eliminate noise from the image without changing the pixels which are uncorrupted by noise.

Step 4 : Then Gabor Filter is applied to the image filtered in the above step 3. This Gabor Filter is mainly used for texture and feature analysis.

Step 5 : Then the exudates segmented image appears which is regarded as the final output image after applying all filters.

Step 6 : At the end, various parameters are evaluated to check the performance of the proposed technique.

Step 7: Finally stop the algorithm.

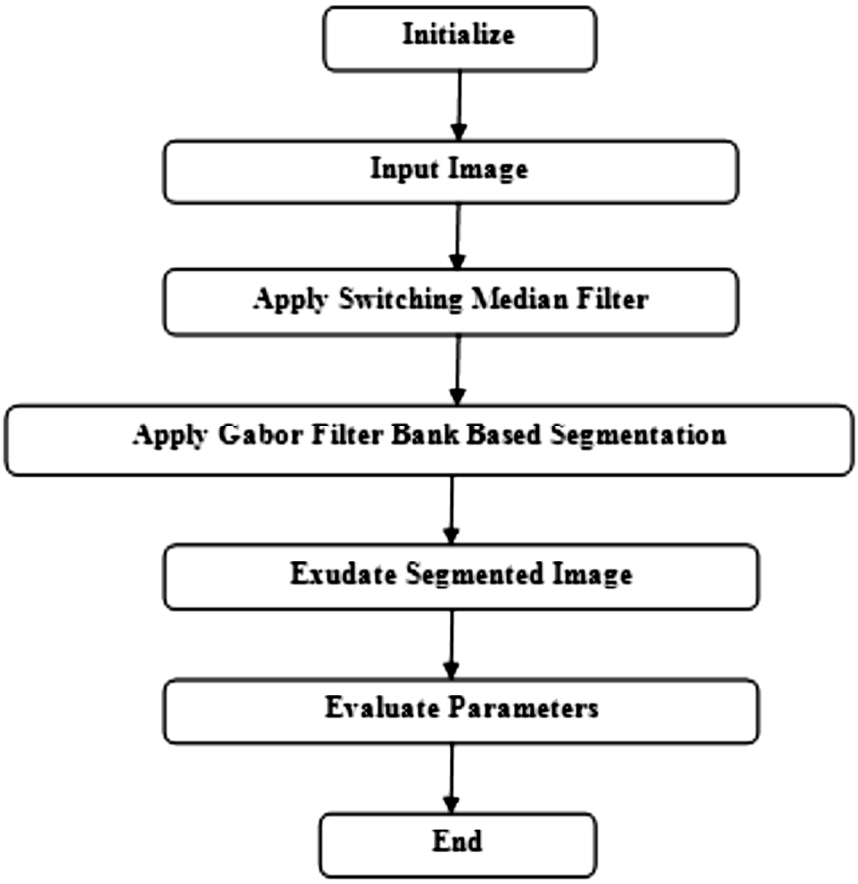
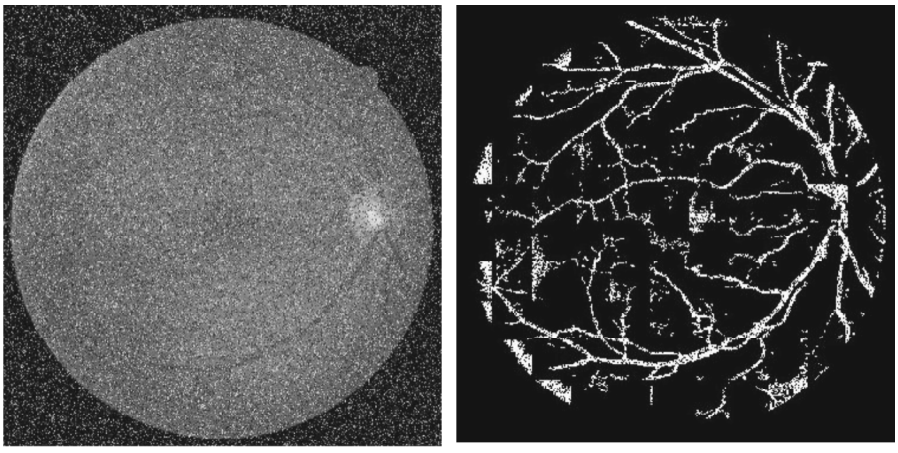


Fig. 1. Flowchart of Proposed Methodology.

4. RESULTS AND DISCUSSIONS

In order to implement the proposed work, the design and implementation has been done in MATLAB using the image processing toolbox. All the implementation is done using a set of images derived from the DRIVE database [10]. In this work a set of 10 images is taken to test the existing and the proposed method.

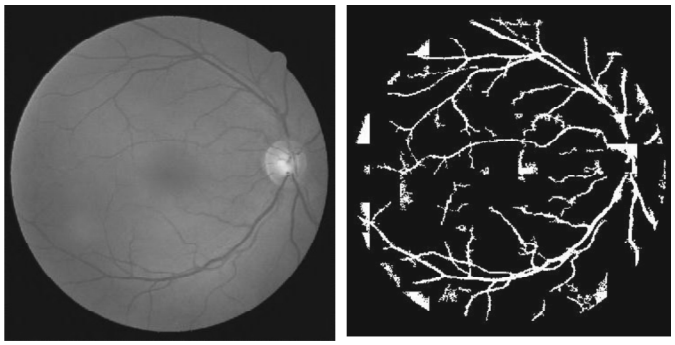


(*a*) (*b*)

Fig. 2. (*a*) Input image with effect of noise (*b*) Noisy Image Segmentation.

In the above Figure 2(*a*), an input image is taken which is affected by salt and pepper noise. This noisy image is taken to carry out the existing as well as the proposed algorithms. It helps us in achieving the results which will prove that the proposed method is better than the other available methods.

In the Figure 2(*b*), it shows the segmented noisy image which illustrates the existing algorithm in which only Gabor Filter is applied to the input image to attain the results. It will give us the results which will be compared with the results of the proposed technique.



(*c*) (*d*)

Fig. 2. (*c*) Image after applying Switching Median Filter (*d*) Final Image after applying proposed technique.

In the Figure 2(*c*), it is showing the input image after applying the Switching Median Filter which is the main basis of our proposed work. It indicates the denoised image.

In the Figure 2(*d*), it shows the final output image. This image is attained as the last image after applying the proposed algorithm. It can be seen that this final image is much more clear than the final image of the existing method. And it is also observed that that the results of the proposed method are much better and clear than the results of the existing method.

5. PERFORMANCE ANALYSIS

This section provides the evaluation of some well known parameters in digital image processing by providing a comparison between the existing and the proposed technique. The following parameters will prove that the proposed technique is better in performance than the existing technique.

A. Sensitivity (SN)

The values of sensitivity are shown below in the comparison table 1. As the sensitivity is increasing in each case which shows that the proposed algorithm is showing improved results in every case.

Figure 3 given below shows the quantized analysis of sensitivity of various images by existing value (in blue) and proposed value (in red). It is clear from the plot that there is increase in the values of sensitivity for various images using the proposed method.

Table 1 Sensitivity

Image No.	*Existing Technique*	*Proposed Technique*
Image 1	0.9713	0.9834
Image 2	0.9647	0.9777
Image 3	0.9611	0.9750
Image 4	0.9554	0.9706
Image 5	0.9624	0.9759
Image 6	0.9513	0.9657
Image 7	0.9679	0.9788
Image 8	0.9629	0.9746
Image 9	0.9643	0.9755
Image 10	0.9641	0.9776

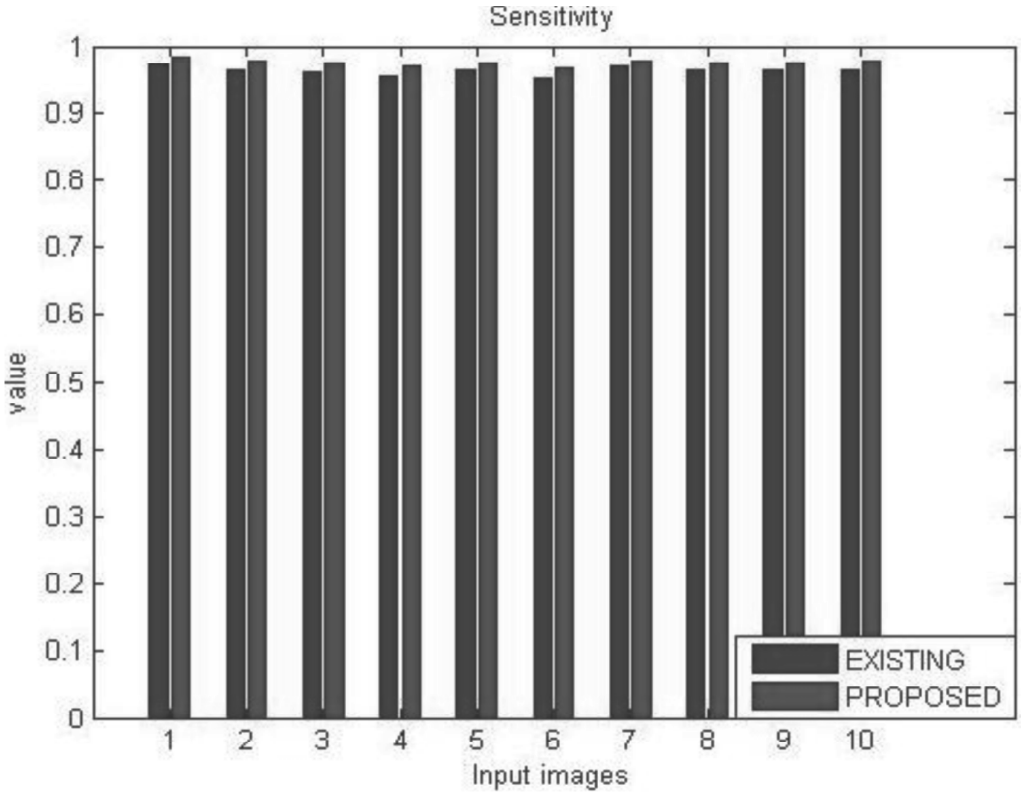


Fig. 3. Sensitivity Graph.

B. Specificity (SP)

The values of specificity are shown below in the comparison table 2. As the specificity is increasing in each case which shows that the proposed technique is showing better results in every case.

Figure 4 shows the quantized analysis of specificity of various images by existing value (in blue) and proposed value (in red). It is clear from the plot that there is increase in the values of specificity for various images using the proposed method. So the proposed method gives improved results over other available methods.

Table 2. Specificity.

Image No.	*Existing Value*	*Proposed Value*
Image 1	0.5759	0.5844
Image 2	0.5997	0.6168
Image 3	0.6106	0.6111
Image 4	0.5846	0.5935
Image 5	0.5194	0.5211
Image 6	0.5372	0.5468
Image 7	0.5101	0.5198
Image 8	0.5310	0.5449
Image 9	0.5602	0.5705
Image 10	0.5342	0.5507

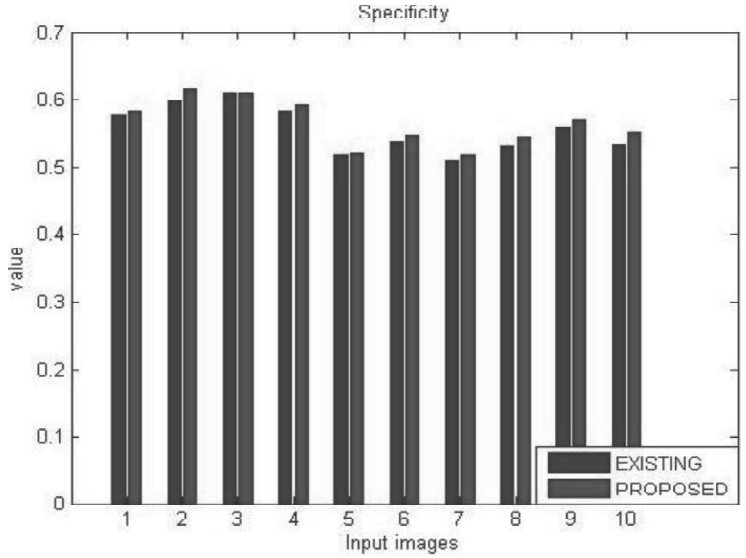


Fig. 4. Specificity Graph.

C. Accuracy (AC)

Table 3. Accuracy.

Image No.	*Existing Value*	*Proposed Value*
Image 1	0.9381	0.9426
Image 2	0.9325	0.9396
Image 3	0.9286	0.9335
Image 4	0.9179	0.9239
Image 5	0.9201	0.9225
Image 6	0.9098	0.9139
Image 7	0.9300	0.9324
Image 8	0.9246	0.9287
Image 9	0.9277	0.9320
Image 10	0.9258	0.9308

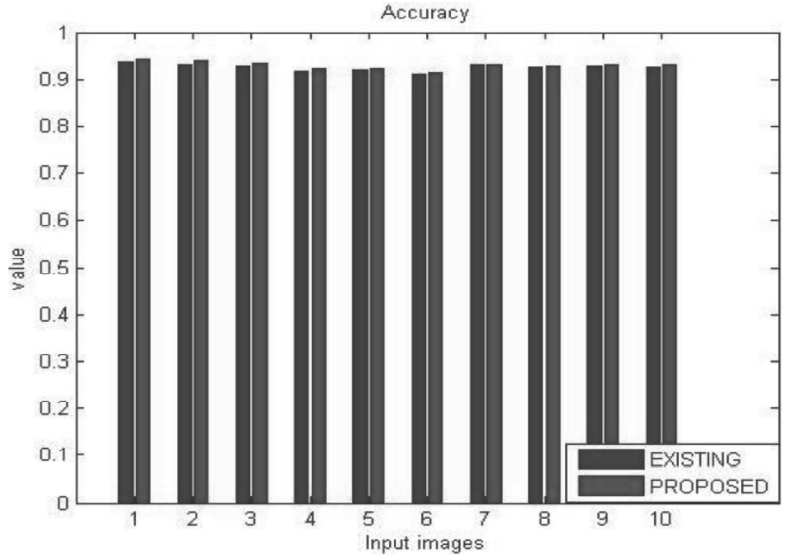


Fig. 5. Accuracy Graph.

The values of accuracy are shown above in the comparison table 3. The table is showing the values of existing method and proposed method for various images. The accuracy value need to be higher, so as the table is showing the increased value of accuracy for the proposed method which indicates that the proposed technique is showing better results.

Figure 5 given above shows the quantized analysis of accuracy of various images by existing value (in blue) and proposed value (in red). It is clear from the plot that there is increase in the values of accuracy for various images using the proposed technique. So the proposed method gives better results over the existing method.

$$SN = TP/ TP + FN$$

$$SP = TN/ TN + FP$$

$$AC = TP + TN/ TP + FN + TN + FP$$

Where SN denotes Sensitivity, SP denotes Specificity, AC is Accuracy.

TP is True Positive, TN indicates True Negative, FN is False Negative and FP indicates False Positive.

4. CONCLUSION

Therefore to improve the accuracy of detecting blood vessels in fundus images further a hybrid Gabor filter bank with switching median filter technique is proposed in this paper. The hybrid Gabor filter bank with switching median filter has used improved switching median filter which enables us to detect blood vessels even in highly corrupted noisy images. The comparison of the existing and proposed techniques is shown in this paper based upon the following quality image metrics- Sensitivity, Specificity and Accuracy. The results show that the proposed technique has shown improved results over the existing technique.

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