

Vasculature Detection from Retinal Color Fundus Images using Linear Prediction Residual Algorithm

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Abstract

Automatic vasculature detection from color fundus images of retina has a significant role in automated diagnosis. Retinal vasculature identification has received importance off late , as it is an important anatomical structure in the analysis of retinopathy. Retinal vasulature can be obtained using any of the basic edge detection techniques but the challenge faced here is in identification of minituare blood vessels . In this paper the applicability of linear prediction residual algorithm for vasculature detection has been analysed. In this case the pixels which fail the prediction are considered as the vasculature edges and are then extracted from the fundus image. The results obtained show that minute blood vessels have also been identified using the proposed approach.

Key Words:Retinal fundus image, vasculature, linear prediction.

1. Introduction

The interior area which lies opposite to the lens area in the eye constitute the fundus region. The fundus region of the eye can be imaged using techniques like fundus photography and ophthalmoscopy. In this paper, we are focusing on the images of the fundus region obtained by fundus photography.

Most of the eye disorders can be obtained by examining the eye fundus region because their affect manifest mostly in the retina. The major motivation behind the enormous research on image processing techniques in ophthalmology is attributed mainly due to the cost involved in eye care provide's diagnosis and the increased number of retinal images to be reviewed for diagnosis. With image analysis techniques applied over the fundus images of eye, it is possible to detect several abnormalities at an early stage. The detection of the vasculature plays an important role in the diagnosis of many eye disorders like the macular degeneration, diabetic retinopathy, identifying cardio-vascular risk factors etc. Analysing the retinal vessel properties or the vasculature details form a primary step in further diagnosis of most of the eye abnormalities. Thus, in this paper we are focussing only on the effective detection of the vascular region from fundus eye images.

The automated vascular region detection is an area having many active research and there are numerous papers which focus on the retinal vessel identification. Matched filter-based vasculature segmentation method for eye fundus images are used to segment the retinal vessels from fundus images[6]. In that method, pre-processing is done using Gabor filter. Then, the pre-processed image is thresholded and a raw segmentation is applied. Then, few elongating filters are applied. Again, this method gives thick to medium vessels with an accuracy of 95.69%[6]. Thus, the main challenge thus is to identify the medium to small vessel regions. So we propose the linear prediction residual algorithm to effectively segment the small vessel regions also from the fundus eye images.

Linear prediction algorithm is mainly used in 1D signal analysis like audio signals. A linear prediction (LP) model [3] predicts/forecasts next values of a pixel, in case of an image by using the previous pixel values that lie horizontally as well as vertically. In a 2D fundus image, the linear prediction is applied both row-wise and column-wise and the prediction errors are taken as the edge regions of the retinal blood vessels which gives the details of thin vasculature regions too.

2. Implementation Details

Dataset Details

The fundus eye images have been obtained from the DRIVE database [6][5]. The DRIVE database has been created keeping in focus the necessity to perform research in the area of ophthalmology. The dataset contains 20 test

images. There are images available for both testing and training. Few sample dataset is provided below in figures 1, 2 and 3.



Fig. 1: Sampe dataset 1



Fig. 2: Sample dataset 2



Fig. 3: Sample dataset 3

Methodology

In the acquired dataset, the LP prediction algorithm is applied row-wise and colum-wise and when there is a perdition error, then, that corresponding pixel is considered as an edge pixel and is identified in the filtered image.

The value of $x(n)$ is found out using a linear combination of N previous samples. The estimate is represented using the following form:

$$\hat{x}(n) = \sum_{i=1}^P a_i x(n-i) \quad (1)$$

where $\hat{x}(n)$ is the predicted signal value, $x(n-i)$ is the previos values of the signal used for predicting the n th value, P is the order of the prediction and a_i is the predictor coefficients.

The error $e(n)$ for the linear prediction can be calculated as follows:

$$e(n) = \| x(n) - \hat{x}(n) \| \quad (2)$$

For all the one-dimensional signals,these equations are valid. So, for an image, the filter is applied vertically and horizontally to obtain the error.

The order of prediction value has been chosen as 20 and the a_i values are found out by the optimization of the RMS(Root Mean Square) criterion, which can also be reffered to as the auto-correlation criterion.

System Diagram

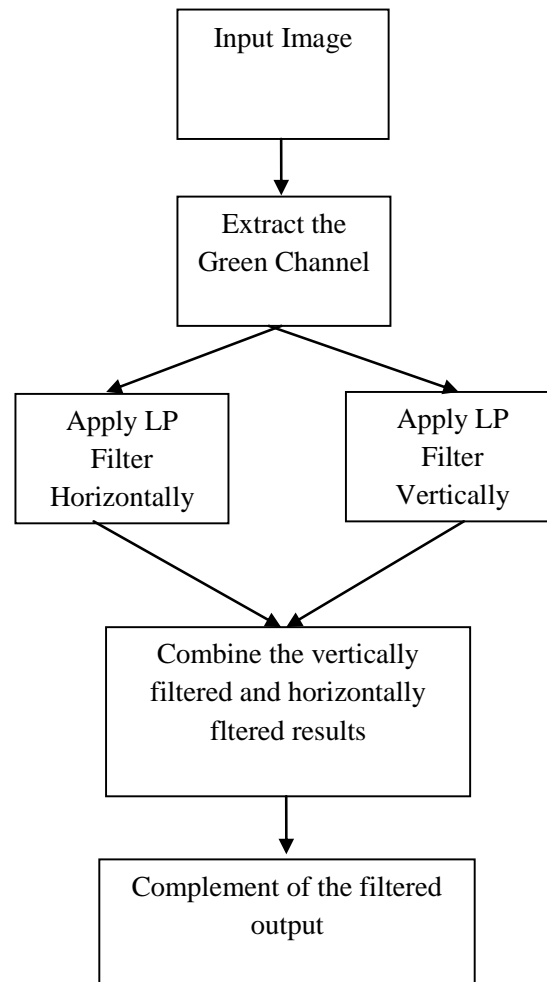


Fig. 4: System Diagram

The input image is an RGB fundus image of the eye. Only the green channel is extracted from the image as it contains maximum intensity information compared to the red and the blue channel. Then, the linear prediction is applied horizontally and vertically over the that and the resultant filtered outputs are added to obtain the final filtered output. The added filtered image contains details of the vasculature.

3. Results

The algorithm is applied over 50 sample images. The results obtained over 2 sample dataset is provided in the following figures. The input image, the corresponding green channel of the color image, the result after combining the vertical and horizontal filtered outputs and the complement of the corresponding resultant filtered output is also provided below.



Fig. 5: Input RGB fundus image (i) of the Eye

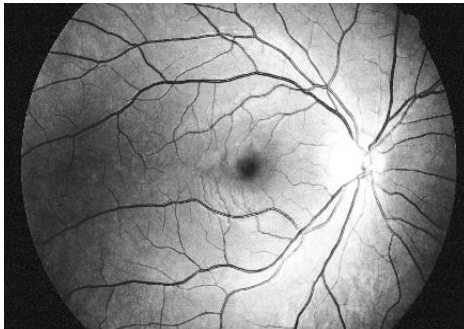


Fig. 6: Green Channel of the Fundus image(i)

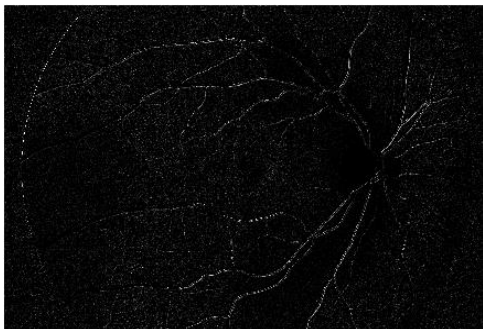


Fig. 7: LP Filtered residual image (i)

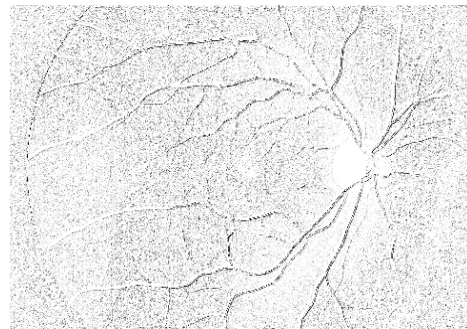


Fig. 8: Complement of Fig.7



Fig. 9: Input RGB fundus image(ii) of the Eye

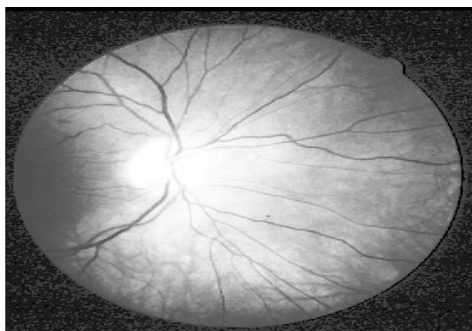


Fig. 10 : Green Channel of the Fundus Image(ii)

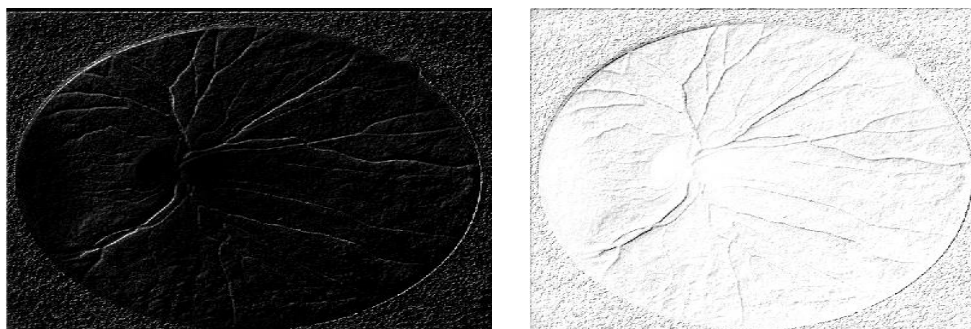


Fig. 11: LP Filtered residual image(ii) Fig. 12 : Complement of Fig.4

Figure 5 and figure 9 show the original RGB input image of the fundus of eye. The green-channel of the corresponding RGB input image is shown in figure 6 and figure 10. The filtered image after combining the residual of linear prediction algorithm applied horizontally and vertically over the images are illustrated in figure 7 and figure 11. For the better visibility of the vasculature, the complement of the filtered residual images are taken, which are shown in figures 8 and 12 for RGB fundus images 1 and 2 respectively. From figures 5 and 9, it can be very well noted that details of the large medium and few small vasculature is obtained using the linear prediction algorithm.

4. Conclusion and Future Work

Linear prediction residual algorithm is an efficient method to extract fine edges from images, like the vasculature from the fundus image of eye. The algorithm detects large as well as the small vasculature edges from the fundus image. The forward as well as backward prediction method can be used as a future work to obtain finer edges.

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