Noise Removal From Optical Coherence Tomography (OCT) Images By Using DIP Techniques

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Abstract- *Optical coherence tomography (OCT) is a non-invasive technique with a large array of applications in clinical imaging and biological tissue visualization. However, the presence of speckle noise affects the analysis of OCT images and their diagnostic utility. In this paper we have collected ten OCT images from Apollo Health City, Hyderabad and then perform the digital image processing techniques to remove noise from images. In proposed algorithm average filter works better to remove speckle noise from OCT images.*

Keywords- OCT, Speckle, Average Filter

I. INTRODUCTION

Optical coherence tomography (OCT) is an optical signal acquisition and processing technique that captures 3D images from within optical scattering media such as biological tissues. In ophthalmology, OCT is used to find detailed images from within the retina. Similar to other optical tomographic techniques, OCT undergoes from speckle noise that reduces the ability of image interpretation [1-5]. Optical Coherence Tomography is a coherence-gated imaging modality with massive applications in biomedicine because of its non-invasive environment and capacity to image micro-scale 3D features [6].

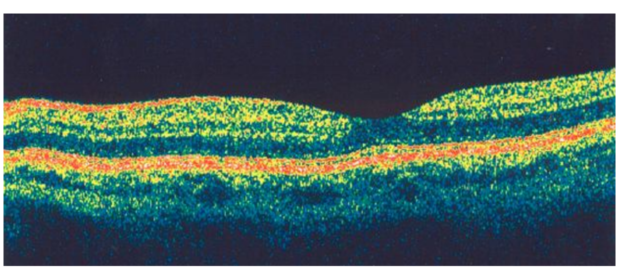


Figure 1: Normal Retina

Above figure is the normal retina. With OCT, ophthalmologist can see the retinas distinctive layers. This permits ophthalmologist to map and measure thickness of retina. These dimensions help with diagnosis. They also deliver treatment guidance for glaucoma and diseases of the retina. These retinal diseases include age-related macular degeneration (AMD) and diabetic eye disease.

a. Macular Holes

The most collective form of angle-closure glaucoma is relative pupillary block. In relative pupillary block, aqueous pressure behind the iris plane forces the iris anteriorly. Exclusion of this pressure gradient can be accomplished with laser iridotomy. A second, less common form of angle-closure glaucoma is known as plateau iris syndrome. In plateau iris, the iris is enforced into the angle by the occurrence of an abnormally placed, anterior ciliary body. Because this form of angle-closure is not due to fluid pressure gradient, it responds poorly to laser iridotomy. If undiagnosed, recurrent angle-closure may develop. Other forms of angle-closure of interest to clinicians comprise lens-induced angle-closure, iris cysts, iris tumors, ciliary body rotation due to effusion, dark room provocative testing during ultrasound biomicroscopy, malignant glaucoma.

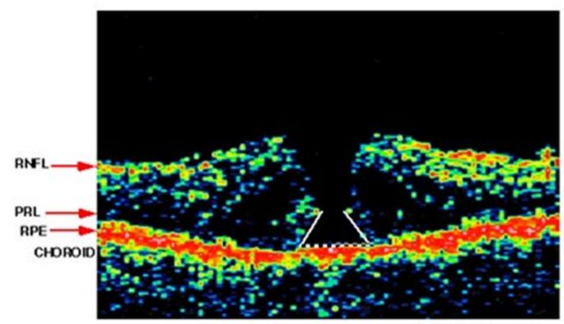


Figure 2: OCT Image

Macular holes are characterized by partial or complete absence of retinal tissue. OCT can offer information about production and the relationship of the posterior hyaloid to the development of the hole. In this preoperative image, a full-thickness hole with cyst formation within the retina is visible.

II. METHODOLOGY

To perform different noise removal filters we have use digital image processing techniques with the help of following expressions.

a. Average Filter: -

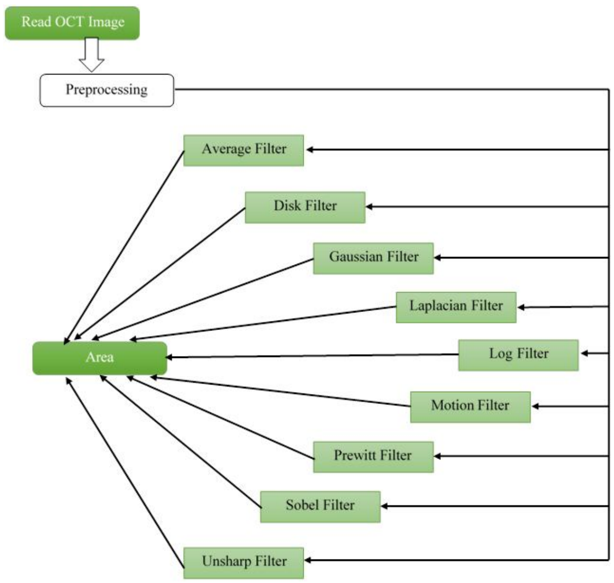


Figure 2: Flow for Noise Removal from OCT Images by Using DIP Techniques

$$g(x,y)=\frac{\sum_{s=-a}^{a}\sum_{t=-b}^{b}w(s,t)f(x+s,y+t)}{\sum_{s=-a}^{a}\sum_{t=-b}^{b}w(s,t)} \quad (1)$$

To generate a complete filtered image this equation must be applied for x = 0,1, 2,..., M-1 and y = 0,1, 2,..., N-1.

b. Gaussian Filter: -

Gaussian filter is spatial filter, which is used for removing the gaussian noise from the images. Gaussian filter is made with the help of following equation

$$h_g(n_1,n_2)=e^{-(n_1^2+n_2^2)/(2\sigma^2)}$$

$$h(n_1,n_2)=\frac{h_g(n_1,n_2)}{\sum_{n_1}\sum_{n_2}h_g} \quad (2)$$

After applying gaussian filter on green channel OCT image, we have apply Laplacian filter. Laplacian filter is also a spatial filter, which is used for extraction of edges of OCT images.

c. Laplacian Filter: -

Laplacian filter is made with the help of following equation.

$$\nabla^2=\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}$$

$$\nabla^2\approx\frac{4}{(\alpha+1)}\begin{bmatrix}\frac{\alpha}{4} & \frac{1-\alpha}{4} & \frac{\alpha}{4}\\ \frac{1-\alpha}{4} & -1 & \frac{1-\alpha}{4}\\ \frac{\alpha}{4} & \frac{1-\alpha}{4} & \frac{\alpha}{4}\end{bmatrix} \quad (3)$$

d. Log Filter: -

Log filter is made with the help of following equation.

$$h_g(n_1,n_2)=e^{-(n_1^2+n_2^2)/(2\sigma^2)}$$

$$h(n_1,n_2)=\frac{(n_1^2+n_2^2-2\sigma^2)h_g(n_1,n_2)}{2\pi\sigma^6\sum_{n_1}\sum_{n_2}h_g} \quad (4)$$

e. Prewitt Filter: -

Prewitt filter is made with the help of following equation.

$$\mathbf{G}_x=\begin{bmatrix}-1 & 0 & +1\\ -1 & 0 & +1\\ -1 & 0 & +1\end{bmatrix}*\mathbf{A} \quad \text{and} \quad \mathbf{G}_y=\begin{bmatrix}-1 & -1 & -1\\ 0 & 0 & 0\\ +1 & +1 & +1\end{bmatrix}*\mathbf{A} \quad (5)$$

f. Sobel Filter: -

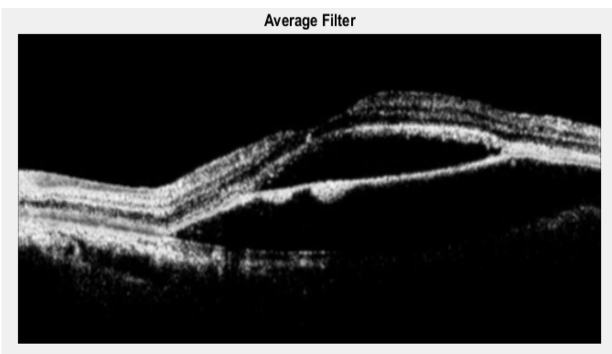
Sobel filter is made with the help of following equation.

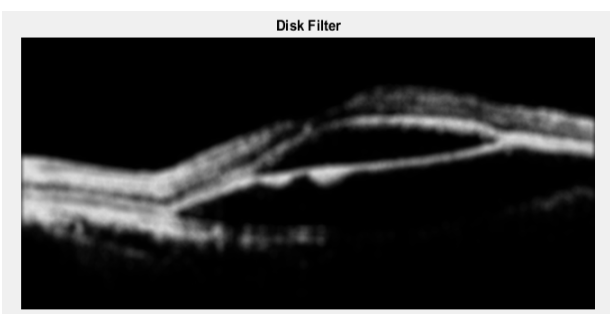
$$\mathbf{G}_x=\begin{bmatrix}+1 & 0 & -1\\ +2 & 0 & -2\\ +1 & 0 & -1\end{bmatrix}*\mathbf{A} \quad \text{and} \quad \mathbf{G}_y=\begin{bmatrix}+1 & +2 & +1\\ 0 & 0 & 0\\ -1 & -2 & -1\end{bmatrix}*\mathbf{A} \quad (6)$$

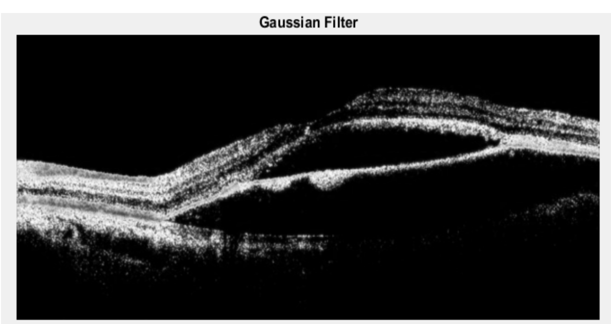
Above figure 3 shows the flow for noise removal from OCT images by using digital image processing techniques. First of all we have read the OCT image then apply preprocessing, in this we have converted 3D image in 2D by using green channel separation. Then apply different noise removal filters such as Average, Disk, Gaussian, Laplacian, Log, Motion, Prewitt, Sobel and Unsharp filter respectively.

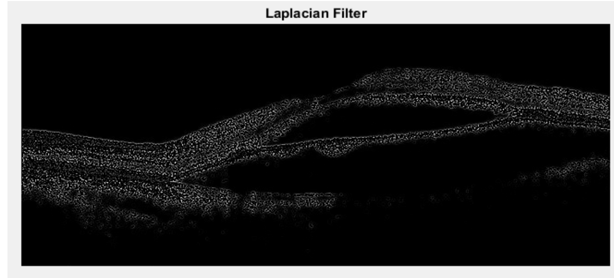
III. RESULT

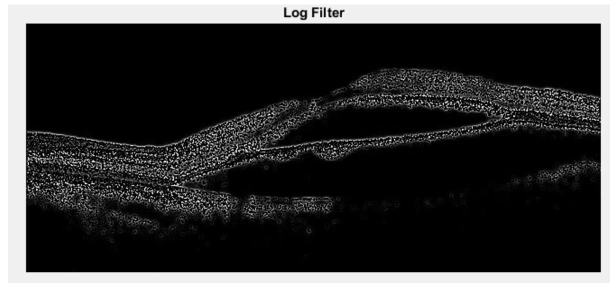
For removal of noise from OCT image, we have use noise removal filters. After preprocessing we have apply all noise removal filters to the OCT image database then extract the area for all filtered images. By observing the area of all filters we found that, average filter gives the good results for removal of speckle noise from all OCT images.

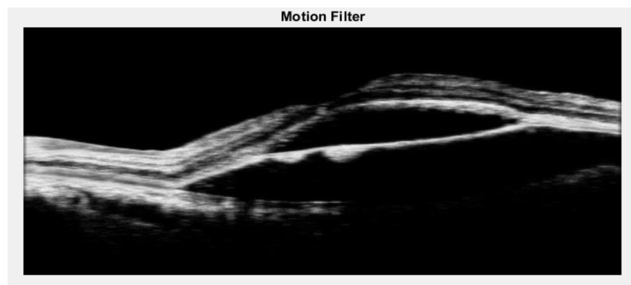


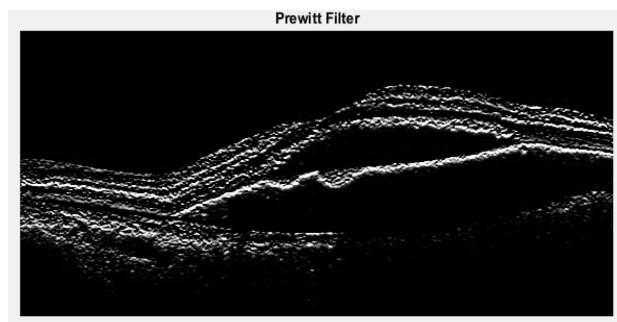


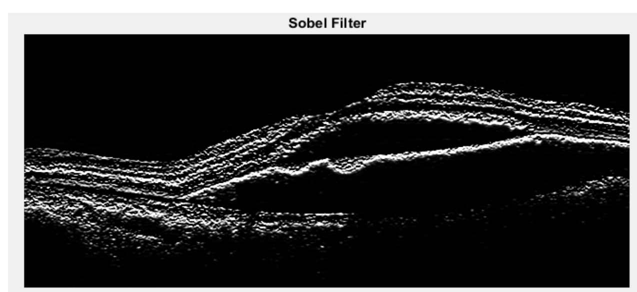












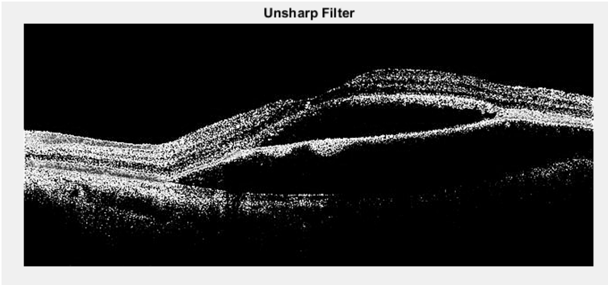
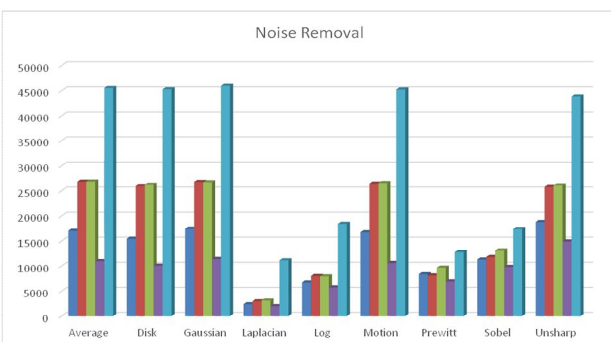


Figure 4: Noise Removal Filters

Table 1: Statistical Areas for Noise Removal Filters

Sr. No.	Average	Disk	Gaussian	Laplacian	Log	Motion	Prewitt	Sobel	Unsharp
1	17029	15467	17404	2403	6723	16714	8357	11310	18770
2	26808	25944	26762	3012	7983	26426	8108	11825	25777
3	26849	26191	26705	3154	7929	26532	9664	13117	26053
4	10997	10078	11433	2014	5759	10618	6942	9815	14913
5	45537	45299	45983	11148	18407	45259	12797	17368	43852
6	25280	24655	25467	2830	7775	25014	10006	13754	26407
7	24994	23873	25143	2995	7801	24825	9100	12492	24993
8	32236	31335	32112	3528	9383	31846	9815	14035	30972
9	28304	26918	28629	3832	10437	27789	10647	15051	30367
10	31833	30877	31755	3515	9381	31393	9669	13933	30698



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