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COMPARISION OF VARIOUS NOISES AND FILTERS FOR FUNDUS IMAGES USING PRE-PROCESSING TECHNIQUES

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ABSTRACT

Denoising an image is the important task in an image processing. Images are noised during the capture and transmission. Image enhancement is the main and primary step in image processing concept. It is used to develop the quality and brightness of an image. Generally fundus images are picked up from various locations, using different cameras. This results in a range of images with diverse quality, in some of the images cannot clearly show or detect the pathologies. The noise removal in the image is the problem based on the noise present in the fundus image. To improve the quality of an image the denoising technique is used to enhance an image. In image processing the removing a noise is a challenge task. Typically we know what type of noise and error on the image, for which in this paper some of the standard noises are used to eliminate noise in an image. In this paper we made an effort to study about the various noises such as Amplifier Noise (Gaussian Noise), Salt and Pepper Noise (Impulsive Noise), Speckle Noise (Multiplicative Noise), Poisson Noise. In this paper various filters (Mean Filter, Median Filter, Gaussian Filter and Wiener Filter) are used to remove noise from fundus images and also compare results with estimation of parametric principles like Mean Square Error (MSE), Normalized Absolute Error (NAE), Normalized Cross Correlations (NK), Peak Signal Noise Ratio (PSNR).The Experiment results shows that wiener and Haar filter arethe best filter for medical and fundus images.

KEYWORDS: Noises, Fundus images, Diabetic Retinopathy, Error, PSNR, Wavelet Transform.

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1. INTRODUCTION

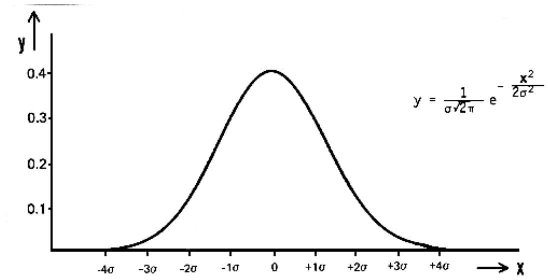
Diabetes is one of the main disease in all around the world. Due to this eye is affected, it happens in retinal changes based on the blood vessels. In which the vessels get damaged, swollen and leak watery or even close completely. Due to Identification of Diabetic retinopathy an images are taken and by connecting a high resolution digital camera to microscope images are captured by changing microscope magnification to get good resolution. For identifying the disease of different retinal types, image processing is used for various retinal types' images. In image processing the first step is image pre-processing. It is done for improving or enhancing the images to satisfy the quality of the image found from various sources. Image denoising is more significant than any other tasks in image processing, analysis and applications[1]. Noise reduction is used to eliminate the noise without dropping more detail in an image. To succeed this in this paper four different Linear filtering techniques on four different noise which can affect the retinal images and calculate the filters performance by using four different performance measures[2]. In Image enhancement the spatial domain is good compare with frequency domain to remove the noises. The simulation is done using MATLAB R2012a version. The past research work the various images are denoised like medical images, underwater image, and remote sensing images. The main content of this work is as follows,in section II types of noise which will be removed from defined filter. In section III describes Number of filters used for the mentioned noises. In section IV describes the investigational results and discussion and finally in section V we give short conclusion and future enhancement.

2. TYPE OF NOISES

Noise to be any degradation in the image signal caused by external disturbance[1].In image processing noises in any image can be gathered depends upon the conditions if it is relying on the dependent content or independent of the underlying content[2].Image enhancement is the process of improving the quality of an image. This is more suitable for some specific application. (i) De- blurring or sharpening of a focused image. (ii)The Edges are detected (iii) Improving the contrast and brightness of the image. During the transmission of an image from one place to another place like wireless transmission, via satellite, or other network cable, due to this we may get some errors. The same kind of issues available in digital retinal images. By using this digital fundus images we may screen and diagnose the diabetic retinopathy and in direction to improve the quality of an images. Generally in fundus images noise presented based on pixel by pixel. So to process these kinds of issues we have different noise types, in this work we have a comparison between the different noises like Gaussian noise, Salt and Pepper Noise, Speckle Noise, Poisson Noise.

2.1. Gaussian noise (White Noise)

Gaussian Noise is also called white noise or normal noise, which is normally distributed. It is an additive noise, it comes from various factors,. This noise only adds the signal not integrates the noise, so it is a cumulative process. Gaussian Noise is the normal (bell) shaped noise, which determines the standard deviation σ.The Probability density function P of a Gaussian Random Variable z is represented by, Gaussian Noise Distribution



$$P_k\ (m) = \frac{1}{\sigma\sqrt{2\pi}}\, e^{-\frac{(m-\mu)^2}{2\sigma^2}} \qquad (1)$$

Where,
m - Grey Level Gaussian Distribution noise
μ - The Mean Value
σ – The Standard Deviation

2.2. Salt&pepper noise (Binary Noise)

Salt and pepper noise generally occurs due to failing of camera sensors cells, during image digitization or transmission synchronization error occurs or failure in memory cells etc. This noise also called impulsive noise or shot noise or binary noise. The presence of an image is scattered unsystematically white or black pixels or both in an image. The intensity value for this noise the 8 bits/pixels image contains the pepper noise and salt noise 0 and 255 respectively. It can be expressed as,

$$P\ (g) = \begin{cases} M_a \\ M_b \\ 0 \end{cases} \qquad (2)$$

In the above equation, g=a, g=b, otherwise respectively.
g – Salt and pepper noise in given image
M_{a-} Bright area in dark pixels
M_b – Dark area in bright pixels

2.3. Speckle Noise (Multiplicative Noise)

The speckle noise is the type of multiplicative noisesIn this random unwanted signal which is multiplied into different relevant signal while capturing and transmission. The speckle noise is mainly recognized in radar imagery and medical images. The product of the mean value can be taken an exponential random variable. Speckle noise is generally defined based on medical survey is image texture. The speckle noise is represented as,

$$K(i,j)= x(i,j) * n(i,j)+ \varepsilon(i,j) \qquad (3)$$

Where (i, j) is the practical image, n (i, j) is the multiplicative factor and ε(i, j) is the additive factor of the speckle noise. Here i and j denotes the axial and neighbouringkeys of an image samples.In radar applications the major problem is speckle noise.

2.4. Poisson Noise

The photon noise is also called shot noise. It is based on Poisson distribution, which generally totally varies from Gaussian noise. Since this is also one of the additive noise. The noises at different pixels are independent to one another. The Poisson noise is typically available in radiography images. In the image sensor the dark current leakage is processed by Poisson noise and it will produce noise type known as “dark shot noise “.

3. ALGORITHMS FOR IMAGE FILTERING

Filtering is performs transforming the pixel intensity values to get the characteristics of Image enhancement, smoothing, Matching template. The Filtering is removing unwanted noises from images. In fundus images are often corrupted by random variations in intensity, illumination, or have poor contrast and can’t be used directly etc.,and noises are detected and removed by various filters. The filter is generally derived from frequency domain in medical images. In image processing the filters are processed either conquer the high frequency filters i.e. Sharpening useful for emphasizing transitions in image intensity or in low frequencies images i.e. Smoothening is reducing the noise and eliminate the small noises. Compare to the frequency domain the spatial domain is very less processing time. In which the image enhancement is performed by spatial domain to achieve the point and mask processing. The two types of filters like linear and nonlinear filters namely. Linear filter is used to remove the certain noises and also sharpening the blur edges. In Linear filtering the processing time is very less and faster processing is achieved and poor edge detection is involved. In non-linear filters the edges are detected very sharply and due to this the time is more to process and slow processing time. In this paper the filtering is achieved by spatial domain rather than the frequency domain.

3.1. AverageFilter (Mean Filter)

The mean filter is linear type filtering method. The mean filter smoothing the image data, it will remove the noise. This filter is mainly used or applied in masks over each pixel in the image one after another. The performance of each pixel mask are averaged together to make distinct pixel from other pixels, hence it is called average filter. Mainly in photographic images (i.e. In fundus photographic images) the grain noises are removed using this mean filter also this filter performs the spatial filtering on each specific pixel in an image using the grey level values in a square or rectangular neighbouringarea in each image pixel.This mean filter also called convolution filter.

3.2. Median Filter

Linear filter combine with other filter reduces the noise in the fundus images. In the median filter the adjacent pixels will be almost same value as the reference pixel. When the linear filter is used the edges are blurred so the problem of blurring edges can be overcome by used non-linear filter. Median filter is a non-linear filter. In the median filter the steps vector median filter. Vector median filter select from the set of vector only. The one of the vector will be closest to all the other vectors. When colour median filter is applied twice the images which are produced are sharp and without noise. Depending upon the noise density the images after the filtering also changes. It is represented as,

$m(u,v) = \text{median}\ \{g(a,b)\}\ ,\ (a,b)\in S_{xy}$ (4)

This filter is very good in removing noise, without the effects of smoothing that can happen with particular smoothing filters, generally salt & pepper noise is removed. The key feature of understanding the algorithm to remember the median filter has their reasons, i) Remove impulsive noise, ii)Smoothing the other noise, iii)Distortion is reduced.

3.3. Weiner Filter (Optimal Filter)

Weiner filter is the mean square errorideal linear filter for images corrupted by additive noise and blurring. The Weinervalue is calculated by the signal and a noise process of the random second order stationary. This filter is always useful in Fourier domain. Weiner filter is optimal low pass filter in flourier transform, in spatial (pixel) type it is applied to difference among an image and a smoothed image. The overall mean square error in the method of reverse filtering and noise flattening is decreased. Weiner filter is performing the linear valuation over the original image. Given a corrupted image x (n, m), one takes the Discrete Fourier Transform (DFT) to obtain A (u, v). The original image band is valued by taking the product of A (u, v) with the Weiner filter W (u, v):

B (u, v) =W (u, v) A (u, v) (4)

Weiner Filter,

$$W(u,v) = \frac{H*(u,v)P_g(u,v)}{|H(u,v)|P_g(u,v)+P_n(u,v)} \quad (5)$$

Frequency domain techniques are particularly useful for removing periodic noise

3.4. Gaussian Filter

It is similar like mean or average filter but it a uses kernel, which represents bell shaped mound (Gaussian).The Gaussian does not have sharp edges at frequency band in which all the higher frequencies are removed.A Gaussian kernel gives less weight to pixels further from the center of the window.Gaussian kernel desires faster computation time. Gaussian filter is based on peak detection. The filters not only correct the amplitude spectrum coefficient but also correct the spectral coefficient. It removes the edge blurring. Gaussian filtering is mainly used in medical images to blur the image and remove the noise clearly. Gaussian function is defined as,

$$G(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{x^2}{2\sigma^2}} \quad (6)$$

Where,σ- Standard Deviation,G(x) – Gaussian Function of DistributionGauss function ever comes equal to zero. It is symmetric function. Gaussian noise is not good or effective to remove the salt and pepper noise. Gaussian filter is also known as linear low pass filter.ie image is smoothed by itself.

3.5. Haar Filter
Wavelet Transform

The window size problem can be overcome using the wavelet transform. When narrow windows are used at high frequency it has better time resolution when wider windows are used at low frequency it has better frequency resolution. The noise density can be reduced when applying the median filter. Recursive median filter does not smear the edges when the noise density is over 50%. But when the window size is fixed the blurring is high and when the window size is small. This is insufficient in suppressing the noisy images.

Haar Wavelet

It is interactive wavelet decomposition images. At the first time to calculate the average get new lower resolution images, repeating the process on the different averages leads to the full decomposition of images. The original images can be reconstructed to a resolution by adding or subtracting the detail coefficient from the lower resolution versions.It can give the high resolution of pixels.

4. EXPERIMENT RESULT AND ANALYSIS

Some 100 retinal images have taken from the DRIVE database for the analysis. Each image is exposed to different noise that mentioned in the previous chapter above. Each retinal images taken and applied the noise and checked with the various types of filters as mentioned above. The filtered images are compared with the various quality performance measures with the original images. Each image has shown the different values for each filter types as shown as follows.

4.1 Performance Measures
A. Mean Square Error (MSE)

The MSE denotes the collective squared error between the compressed and the original image, whereas PSNR denotes anamount of the highest error. The lower the value of MSE, the lesser the error.To compute the PSNR, the block first computes the mean-squared error using the subsequent equation:

$$MSE = \frac{\sum_{X,Y}[I_1(a,b) - I_2(a,b)]^2}{A*B} \quad (7)$$

A and B are the number of rows and columns in the input images, respectively.

Table 1
MSE Value for images related to different noises with different filters

MSE Value				
Filter/Noise	**Salt & Pepper Noise**	**Gaussian Noise**	**Poisson Noise**	**Speckle Noise**
Mean Filter	93.4129	99.7794	13.1485	6.9875
Median Filter	1.0311	80.9181	29.2698	9.3372
Weiner Filter	287.2822	107.0784	32.6489	12.8201
Gaussian Filter	72.1603	87.844	10.3035	5.7211
Haar Filter	25.0987	75.9231	14.7632	6.7891

Figure 1 indicates the table 1 graphical representation Figure. In which the MSE value of the image is showing the lowest value with respect to median filter over salt and pepper noise. But for all other type of noise image represents lowest value for Gaussian filter. Haar filter, Weiner filter shows average performance over all type of noise also followed by mean filter.

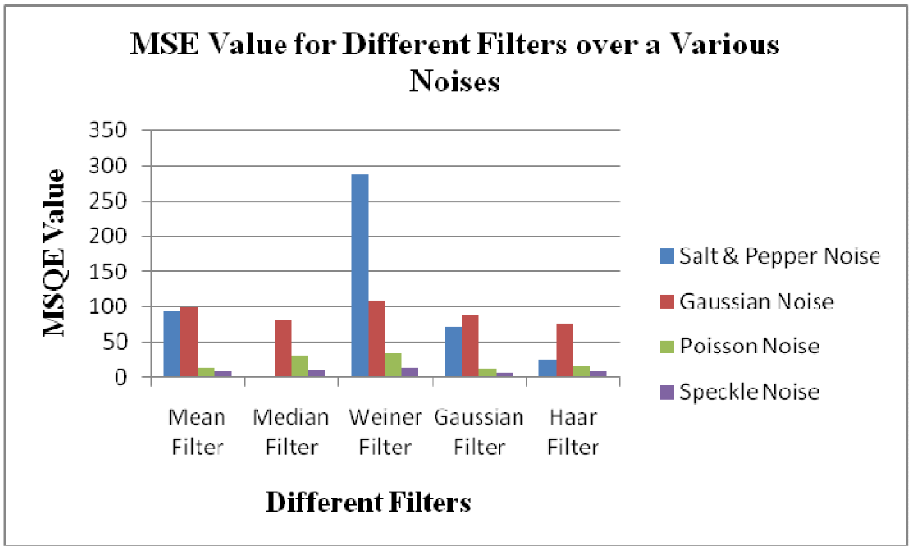


Figure 1
MSE Value for images related to different noises with different filters

B. Peak Signal to Noise Ratio (PSNR)
The PSNR is termed as peak signal to noise ratio is represented in the form of between maximum power of a signal and representation of corrupted noise. The reconstruction of image is performed to improve the quality of measure. The PSNR value is generally represented by reconstruction of higher resolution or quality image. The PSNR value should be always between the range of 30DB and 50DB. The PSNR value is measured using decibel and the value always should be higher. The higher valueof the PSNR, the better the quality of the compressed or recreatedimage. Then the block computes the PSNR using the subsequent equation:

$$PSNR=10\log_{10}\left(\frac{X^2}{MSE}\right) \quad (8)$$

X is the maximum variation in the input image data type. Incase, if the input image has a double-precision floating-point and 8- bit unsigned integer then X is 1 and 255 respectively.

Table 2
PSNR Value for images related to different noises with different filters

PSNR Value				
Filter/Noise	**Salt & Pepper Noise**	**Gaussian Noise**	**Poisson Noise**	**Speckle Noise**
Mean Filter	28.3925	28.151	36.9497	39.6813
Median Filter	48.0857	29.0738	33.4819	38.4002
Weiner Filter	23.5249	27.8382	33.0079	37.0661
Gaussian Filter	29.5146	28.7055	38.0005	40.5475
Haar Filter	48.0903	31.0987	38.1452	40.6098

Figure 2 represents the pictorial representation of Table 2. The PSNR value is higher in median filter over the salt and pepper noise. Gaussian filter gives the highest value for the all other type of noises over the image. Wiener filter and mean filter shows the average performance over the all other types of noise. In this performance PSNR measures it is clear that the best result in haar filter &median filter over a salt and pepper noise only and Gaussian filter remove the Speckle noise, Poisson Noise and Gaussian Noise than other filters.

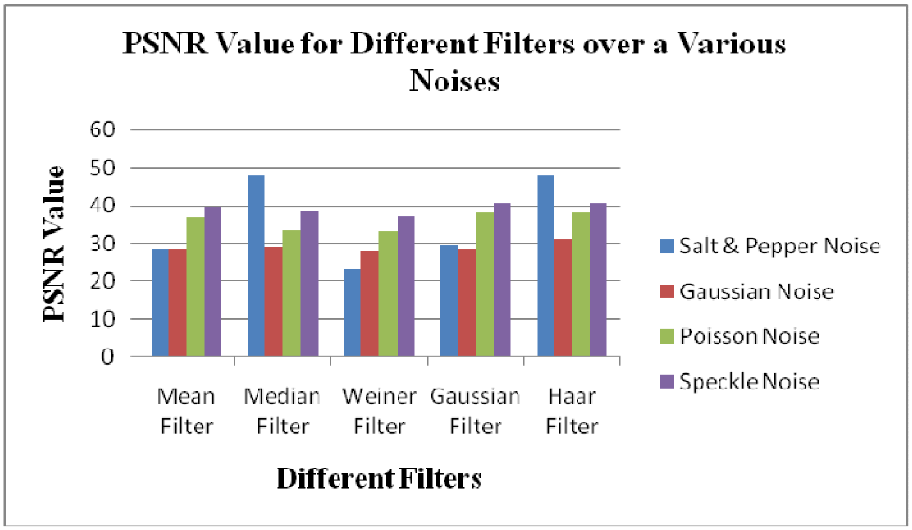


Figure 2
PSNR Value for images related to different noises with different filters

C. Normalized Cross Correlation (NCC)

The relationship between the two different images is calculated based on correlation coefficients. Cross correlation is the similarity measures of two images under various intensity illuminations. The Correlation can be calculated based on the two set of variables, in the fundus images the intensity and quality can be taken for the process. The normalized correlation measures are calculated between the two images based on mean and standard deviation by subtracting and dividing respectively. The normalized patches of image pixel intensity range between -1 to 1(positive and negative).

$$\frac{1}{a}\sum_{m,n}\frac{\left(f(m,n)-\bar{f}\right)\left(t(m,n)-\bar{t}\right)}{\sigma_f\sigma_t} \quad (9)$$

Where a – No. of pixels in t(m,n) and f(m,n)
$\bar{f}$ - Average of f. σ_f – Standard Deviation of f.

Table 3
NCC Value for images related to different noises with different filters

NCC Value				
Filter/Noise	**Salt & Pepper Noise**	**Gaussian Noise**	**Poisson Noise**	**Speckle Noise**
Mean Filter	1.0046	1.0002	0.999	0.9991
Median Filter	0.9997	1.0000	0.9987	0.9992
Weiner Filter	1.0039	1.0000	0.9993	0.9994
Gaussian Filter	1.0044	1.0001	0.9989	0.999
Haar Filter	0.9891	0.9987	0.9895	0.9989

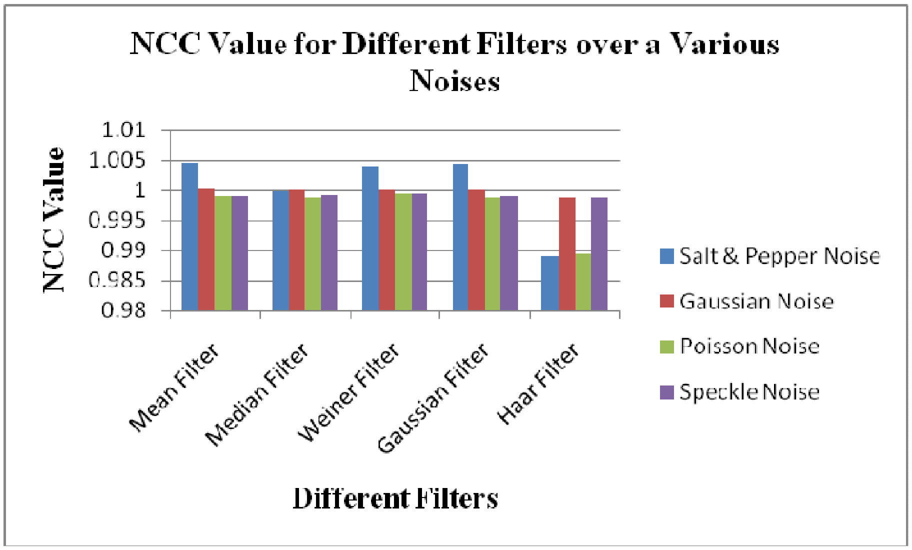


Figure 3
NCC Value for images related to different noises with different filters

Figure 3 shows the pictorial representation of Table 3.The NCC value of a projected image exposed to median filter over all the other types of noise shows 1 or near to 1, which is followed by all the other type of filter.

D. Normalized Absolute Error (NAE)
Normalized absolute error is minimum value in which the variance between original image and normalized image. It is measure of original image value should be less or zero compared with denoised image. The Normalized Absolute Error (NAE) is represented as,

$$NAE=\frac{\sum_{i=1}^{n} abs(A_i-B_i)}{\sum_{i-1}^{n} B_i} \qquad (10)$$

The value close to zero represents better method. The larger value represents poor quality of the image.

Table 4
NAE Value for images related to different noises with different filters

NAE Value				
Filter/Noise	**Salt & Pepper Noise**	**Gaussian Noise**	**Poisson Noise**	**Speckle Noise**
Mean Filter	0.0859	0.1737	0.0329	0.0431
Median Filter	0.0113	0.1308	0.0387	0.0636
Weiner Filter	0.0822	0.1828	0.0415	0.0649
Gaussian Filter	0.0814	0.1651	0.0293	0.038
Haar Filter	0.0105	0.1197	0.0245	0.0578

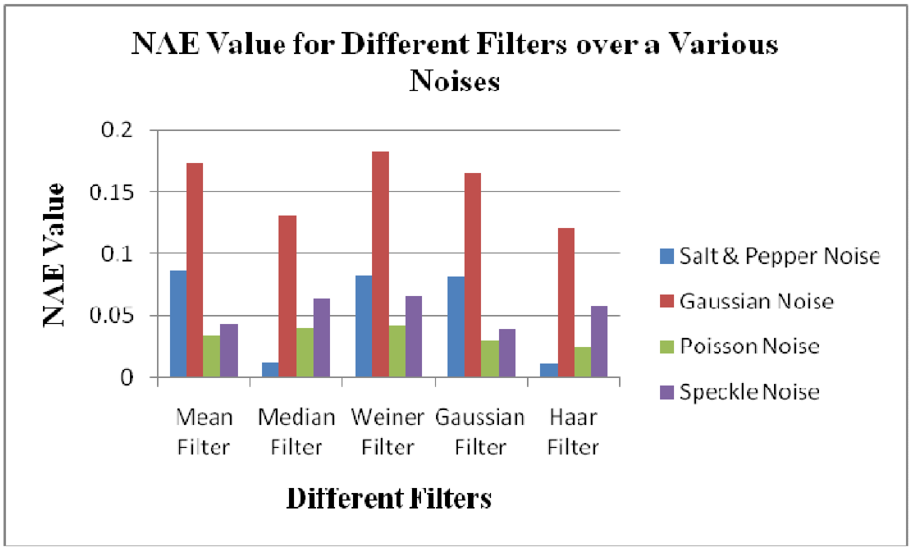


Figure 4
NAE Value for images related to different noises with different filters

Figure 4 shows the graphical representation of Table 4.The NAE value of an image represented to median filter and haarfilter over salt and pepper noise have the least value. For all the other type of noise type the Gaussian filter shows the lowest value for Normalized Absolute error. Mean and Wiener filter shows the average performance over all the type of noise.

5. CONCLUSION

The various linear and non-linear filters are used to denoise a medical imaging. This paper compares the various noises like Gaussian, Salt and pepper, Poisson and Speckle noise which is denoised by different filters Median, Mean (Average filter), Wiener filter ,Haar Filter and Gaussian filter. In which the fundus image denoised by using different filters. From the results shown above with various performance over salt & pepper noise is clear that the median filter shows best results. In the fundus images the wiener filter and Haar filter shows the good performance over the all other three noises. Hence concludes in this paper the haar and wiener filter is a low pass filter and an optimum filter that can be best to apply to all fundus images or medical images. In future the state-of-art filter methods are used for denoising an image to give better performance over all type of noises.

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