



Article Title: Denoising of Diabetic Retinopathy Images Using Adaptive Median Filter

Denoising of Diabetic Retinopathy Images Using Adaptive Median Filter

Anuja S B¹, Dr F Ramesh Dhanaseelan²

¹Assistant Professor, Department of Computer Applications, Narayanaguru College of Engineering, Manjalumoodu, Kanyakumari District, Tamil nadu

²Professor, Department of Computer Applications, St Xavier's Catholic College of Engineering, Chungankadai, Kanyakumari District, Tamil nadu

ABSTRACT

One of the fundamental challenges in the field of Image Processing and Computer Vision is Image Denoising. The goal is to estimate the original image by removing or suppressing noise from a noise-contaminated version of the image. Noise can be introduced into an image during acquisition, processing, or transmission which can reduce the image quality and make it difficult to interpret. Diagnosing retinal diseases of the eye requires analyzing tiny retinal vessels. The digital color present in the images, and retinal vasculature is difficult to be analyzed. This paper discusses various denoising methods to improve the quality of the retinal fundus images before further processing. By selecting a suitable method for denoising, the image details are not lost as well as the contrast is maintained. Based on the performance of several techniques for denoising fundus images, it is found that the Adaptive Median Filter shows a greater performance compared with state of art methods.

Keywords: Noise reduction, Diabetic retinopathy images, Peak Signal to Noise Ratio, Adaptive Median Filter.

1 Introduction

Globally, diabetic retinopathy is the leading cause of preventable blindness in adults aged 20–74 years. With the goal of early detection, regular screening is recommended by major organizations. A regular screening is crucial to prevent blindness [1]. We use color fundus photographs to predict the risk of developing diabetic retinopathy. Signs of retinal microvascular changes caused by diabetes are visible in color fundus photographs, which are routinely used to assess the stage of diabetic retinopathy. Diabetic retinopathy is an eye condition that can cause vision loss and blindness in people who have diabetes [2]. It affects blood vessels in the retina. This progressive eye disease may lead to blurred vision or even irreversible vision loss. Regular eye exams are important, because, by the time noticeable symptoms appear, vision loss may have occurred. There are two types of diabetic retinopathy, which progresses in four stages. The two types of diabetic retinopathy are non-proliferative and proliferative [3]. No proliferative refers to the early stages of the disease, while



Article Title: Denoising of Diabetic Retinopathy Images Using Adaptive Median Filter

proliferative is an advanced form of the disease. The various stages of diabetic retinopathy images are shown in the Figure 1.

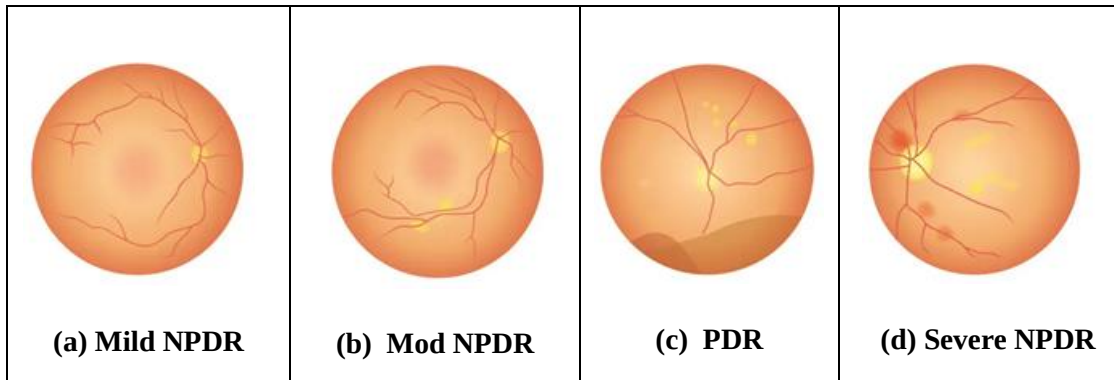


Figure 1: Images representing various stage of Diabetic retinopathy

As shown in Figure 1, Mild non proliferate diabetic retinopathy is the earliest stage of diabetic retinopathy, characterized by tiny swellings/bulges in the blood vessels of the retina. These areas of swelling are known as micro aneurysms. These micro aneurysms can cause small amounts of fluid to leak into the retina, triggering swelling of the macula – the back of the retina. The next stage is moderate non proliferate diabetic retinopathy, here the tiny blood vessels further swell up, blocking blood flow to the retina and preventing proper nourishment [1,2]. This stage will only cause noticeable signs if there is a build-up of blood and other fluids in the macula, causing vision to become blurry. The next stage is, Severe non proliferate diabetic retinopathy, during this stage, a larger section of blood vessels in the retina becomes blocked, causing a significant decrease in blood flow to this area. The lack of blood triggers a signal to the body to start growing new blood vessels in the retina. These new blood vessels are extremely thin and fragile and cause retinal swelling, resulting in noticeably blurry vision, dark spots and even patches of vision loss. If these vessels leak into the macula, sudden and permanent vision loss may occur. At this stage, there is a high chance of irreversible vision loss. The advanced stage of the disease is, Proliferative diabetic retinopathy in this stage new blood vessels continue to grow in the retina. These blood vessels, which are thin and weak and prone to bleeding, cause scar tissue to form inside the eye. This scar tissue can pull the retina away from the back of your eye, causing retinal detachment. A detached retina typically results in blurriness, reduced field of vision, and even permanent blindness. This is a challenging task because noise may be present in the fundus images therefore, we need to denoise it using various denoising techniques. Image denoising is one of the preprocessing methods in image processing.

Currently various denoising methods are used and some of them are mean filter, wiener filter, median filter and gaussian filter. The disadvantages of mean filters are that in the presence of small signal-to-noise ratios they tend to break up image edges and produce false noise edges,



Article Title: Denoising of Diabetic Retinopathy Images Using Adaptive Median Filter

and they cannot suppress medium-tailed (Gaussian) noise distributions. Gaussian filter can cause image blurring therefore the image loses fine detail and contrast. It does not handle 'impulse noise' well. Median filter gives better results in less time in comparison to a Gaussian filter. But of the main disadvantages of using a wiener filter is that it requires a priori knowledge of the power spectra of the input signal, the noise signal, and the true signal. This can be difficult or impractical to obtain in many cases.

Median filter is the most commonly used filter. For denoising the size of the kernel can be of $n \times n$ size which is made to convolve or slide over a $m \times m$ corrupted image. While performing this operation the median value of $n \times n$ kernel on the image is obtained and then the value of a particular pixel is replaced with the median value of the $n \times n$ kernel. But the major issues with median filter are: It is effective only when the noise is impulse noise and its output quality deteriorates when the noise is more than 20%. Moreover, it does not work efficiently when the spatial density of noise is high and for large kernel size, there is no proper smoothening of the image instead valuable information from the image gets blur. All the drawbacks of the denoising filters can be overcome by using Adaptive mean filter.

The main advantages of adaptive median filter are the size of the kernel surrounding the corrupted image is variable due to which better output result is obtained. Unlike median filter it does not replace all the pixel values with the median value. The working of adaptive filter is a two-step process; in the first step it finds the median value for the kernel and in the second step it checks whether the current pixel value is an impulse noise or not. If pixel value is corrupted then it changes its value with median or else it retains the value of the gray scale pixel. By doing this, one can ensure that only the pixels with impulse noise is changed while all other pixel values are retained as they are. This paper proposes a novel effective method for denoising diabetic retinopathy images. Our suggested method gives more effective methods and it is evaluated through subjective vision and objective metric.

2 Recent Works

In 2011 NasrulHumaimi Mahmood; Muhammad Rusydi Muhammad Razif; Mohammad Tajuddin AsmNagoorGany, median filter is used for denoising ultrasound image. But the median filter being a spatial filtering operation, uses a 2-D mask that is applied to each pixel in the input image. It is used to remove defects and noise from pictures. Median filter is much less sensitive than the mean to extreme values (called outliers), therefore it is better without reducing the sharpness of the image and edge preserving nature [5].

Suman Shrestha (Year 2014) used Median filtering for denoising two-dimensional image. Median filtering works fine when the noise intensity is less but it starts to fail when the noise intensity in the image is high [12]. In 2019, HetviSoni and Darshana Sankhe, checked image restoration using the median filter and found the following drawbacks – Median filter is



Article Title: Denoising of Diabetic Retinopathy Images Using Adaptive Median Filter

effective only when the noise is impulse noise (salt and pepper). Its output quality deteriorates when the noise is more than 20%. It does not work efficiently when the spatial density of noise is high. For large kernel size, there is no proper smoothing of the image instead valuable information from the image gets blur [4].

Mukesh Chandra Arya & Ashish Semwal, and, Pauri Garhwal. (2017) put forward the Wiener filter and Average Filter. Wiener filters are one of the ancient methods for noise cancellation but it requires high complexity and speed was low. Wiener filter gives an approximately desired signal as output but it has to compute autocorrelation, cross-correlation, and matrix inversion to yield results. Therefore, noise filtering is not optimal for a wiener filter. Also, the average filter or mean filter is simple and easy to understand. It performs image smoothing. An average filter replaces each pixel with the average of pixels in a square window surrounding these pixels, a larger window can noise removing more effectively but also blur the image [11].

Mukesh Chandra Arya & Ashish Semwal (2017), used a Mean filter or Average filter. It is simple and easy to understand and it performs image smoothing (i.e. sinking variation of intensity between one pixel and the next). The average filter replaces each pixel with the average of pixels in a square window surrounding these pixels. A larger window can do noise removal more effectively, but the disadvantage is that It blurs the image [11].

Pyushi Singhal; Akhilesh Verma and Akash Garg, (2017) proposed a Gaussian filter for a Study to Find the effectiveness of the Gaussian Blur Filter over the Bilateral Filter in Natural Scenes for Graph-Based Image Segmentation, here the blur depends on the size of the window. If is small, blurring will also be less and if is large blurring will also be high [10].

Sandeep Chand Kumainy, Maheep Singh, Krishan Kumar, and Navjot Singh (Year 2018), for a better analysis of an image, performed perform preprocessing with the mean filter to reduce the effect of outliers. It is observed that the simple Mean filter is not performing well in most of the noisy images, one of the main problems with the mean is it is much affected by the outliers [9].

AkulaSuneetha and Srinivaas Reddy (Year 2020), used several filters such as median filter, Gaussian filter, etc. for Image denoising to effectively preserve the image edges to a higher extent in the flat regions and to improve the smoothness of digital image, but these filters failed to preserve the image edges while removing noise [8].

Yudai Yamaguchi, Ichiro Yoshida and Yuki Kondo (2021) proposed a non-local mean filter (NLMF) as a noise reduction filter for images that can preserve edges. The NLMF has high denoising performance for weak noise. However, the NLMF has low denoising performance for strong noise. In addition, the NLMF had a problem in that the amount of calculation was large and the processing time was long [7].



Article Title: Denoising of Diabetic Retinopathy Images Using Adaptive Median Filter

3 Proposed Work

The block diagram of the proposed methodology is shown in Figure 2



Figure 2: Block diagram of proposed methodology

An adaptive median filter performs spatial processing to reduce noise in an image. The filter compares each pixel in the image to the surrounding pixels. If one of the pixel values differ significantly from the majority of the surrounding pixels, the pixel is treated as noise. The other main advantage of adaptive filter is that unlike median filter it does not replace all the pixel values with the median value.

The working of adaptive filter is a two-step process; in the first step it finds the median value for the kernel and in the second step it checks whether the current pixel value is an impulse (salt and pepper noise) or not. If pixel value is corrupted then it changes it value with median or else it retains the value of the gray scale pixel. By doing this, one can ensure that only the pixels with impulse noise is changed while all other pixel values are retained as they are.

3.1 Implementation of adaptive median filter

Z_{min} = Minimum gray level value in S_{xy} .

Z_{max} = Maximum gray level value in S_{xy}

Z_{med} = Median of gray levels in S_{xy}

Z_{xy} = gray level at coordinates (x, y)

S_{max} = Maximum allowed size of S_{xy}

The adaptive median filter works in two levels denoted Level A and Level B as follows:

Level A: $A1 = Z_{med} - Z_{min}$

$A2 = Z_{Amed} - Z_{Amax}$

If $A1 > 0$ AND $A2 < 0$, Go to level B

Else increase the window size

If window size $\leq S_{max}$ repeat level A

Else output Z_{xy} .

Level B: $B1 = Z_{xy} - Z_{min}$

$B2 = Z_{xy} - Z_{min}$

If $B1 > 0$ And $B2 < 0$ output Z_{xy}

Else output Z_{med} .



Article Title: Denoising of Diabetic Retinopathy Images Using Adaptive Median Filter

Level A determines if the output of the median filter, Z_{med} is an impulse or not (black and white) If it is not an impulse noise, we goto level B. If it is an impulse window size is increased until it reaches S_{max} or Z_{med} is not an impulse. The smaller the density of noise is the larger the support S_{max} . We expect not to have an impulse. Level B determines if the pixel value at (x, y) , that is Z_{xy} is an impulse or not. If it is not an impulse, the algorithm outputs the unchanged pixel value Z_{xy} . If it is an impulse the algorithm outputs the median Z_{med} .

4 Results and Discussion

This section gives a brief description about the results of experiments using various denoising filters like Mean filter, Wiener filter, Gaussian filter, Median filter and Adaptive median filter. This work is implemented using MATLAB R2018A and PC with i3 processor.

Denoising is necessary to remove unwanted noise from the image to analyze it in a better form. It refers to one of the major pre-processing steps. However, since noise, edge, and texture are high-frequency components, it is difficult to distinguish them in the process of denoising and the denoised images could inevitably lose some details. Therefore, we need to restore the images using suitable denoising techniques. Different denoising methods are used for retinal image enhancement. The denoised images hence obtained using different types of denoising filters are shown in Figure 3 and Figure 4.

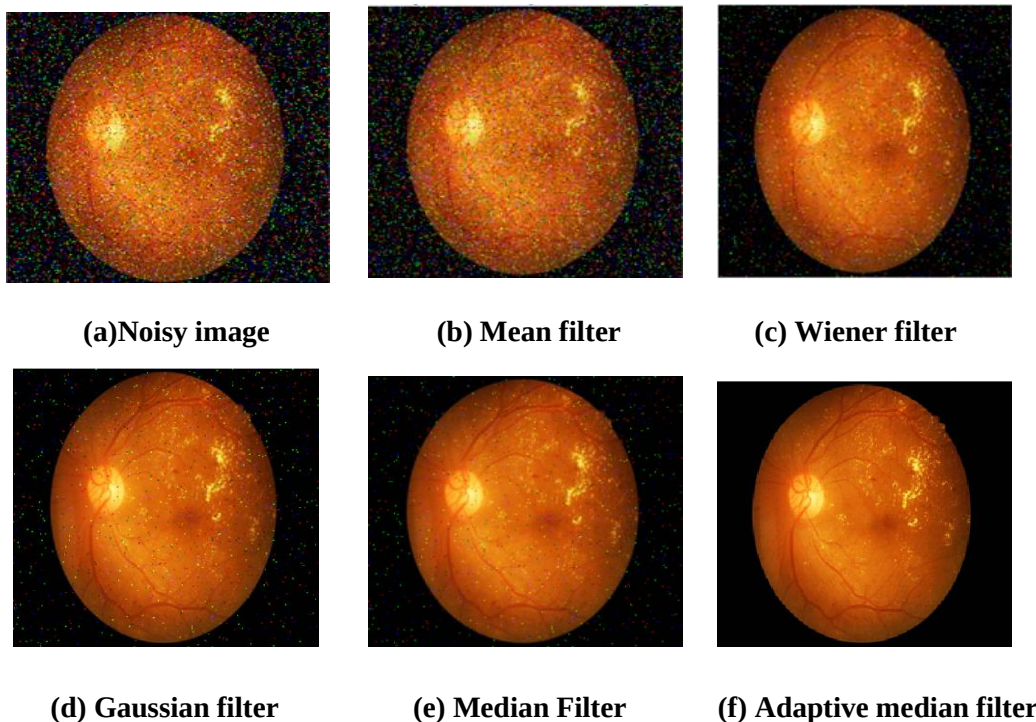


Figure 3: Various Filtered Images of Retinal Image1



Article Title: Denoising of Diabetic Retinopathy Images Using Adaptive Median Filter

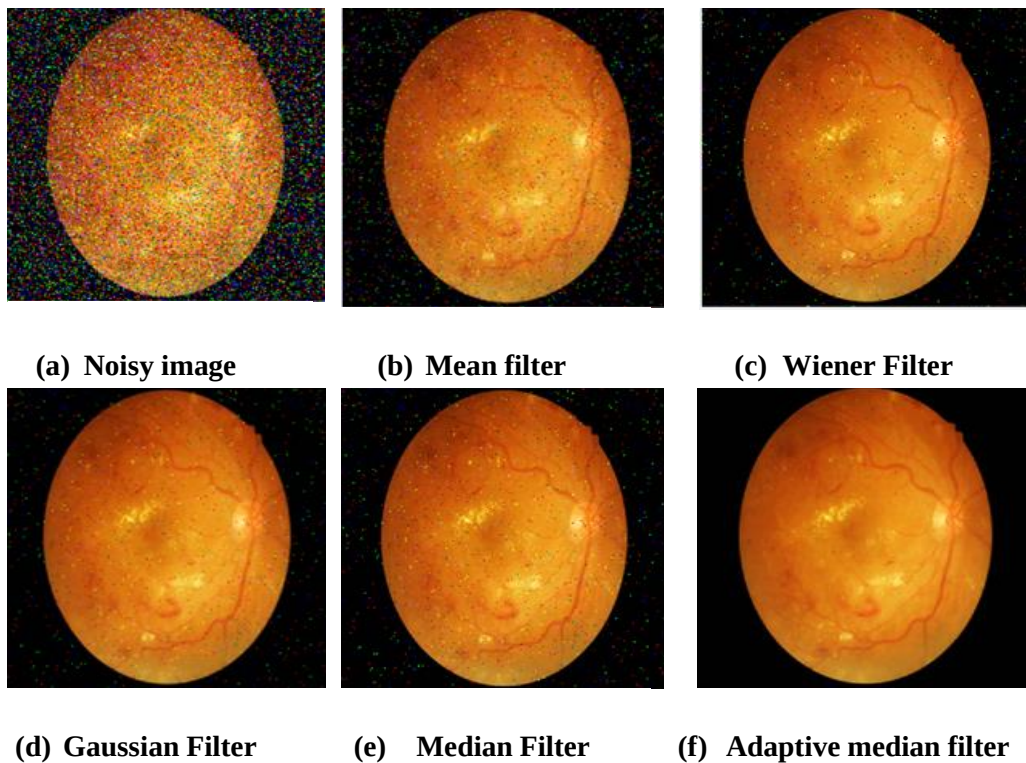


Figure 4: *Various Filtered Image of Retinal Image 2*

Here we used different filters for denoising the two diabetic retinopathy images obtained using a retinal fundus camera. The filters we used here are the Mean filter, median filter, wiener filter, gaussian filter, and adaptive median filter. We calculated the PSNR value of each denoised image using the abovementioned filters. The adaptive median filters showed a high PSNR value compared with other filters. The comparative study of using various filters in our diabetic retinopathy is given in Figure 3 and Figure 4.

4.1 PSNR (Peak signal to noise ratio)

PSNR is a ratio between the maximum possible value and the value of the corrupting noise of an image which PSNR is used to measure the quality of an image. Here the value represents the power of an image. It was usually expressed regarding logarithmic decibel scales, due to the wide dynamic range of many signals. It was proved that a filter having a higher PSNR value is considered to be the best filter.

$$\text{PSNR} = 10 \log_{10}(\text{R}^2/\text{MSE}) \quad (1)$$

4.2 MSE (mean square error)

MSE of a filter is used to evaluate the difference between true value and the value implied by a filter.



Article Title: Denoising of Diabetic Retinopathy Images Using Adaptive Median Filter

$$MSE = \frac{1}{MN} \sum_{i=1}^M \sum_{j=1}^N (x_{ij} - y_{ij})^2 \quad (2)$$

Image size given as input is in size $M \times N$, where x_{ij} and y_{ij} are the initial image and the reconstructed image respectively. Table 1 shows the comparison of the denoising methods. PSNR value is used for measurement of the efficiency of various methods. The graph obtained by plotting the PSNR value against input images is given in the Figure 5.

Table 1: Comparison of PSNR value of denoised images using various filters

PSNR(DB)		
Filters	Image 1	Image 2
Mean filter	33.01	31.88
Wiener filter	32.72	31.80
Gaussian filter	43.60	43.30
Median filter	39.65	42.29
Adaptive median filter	43.71	46.17

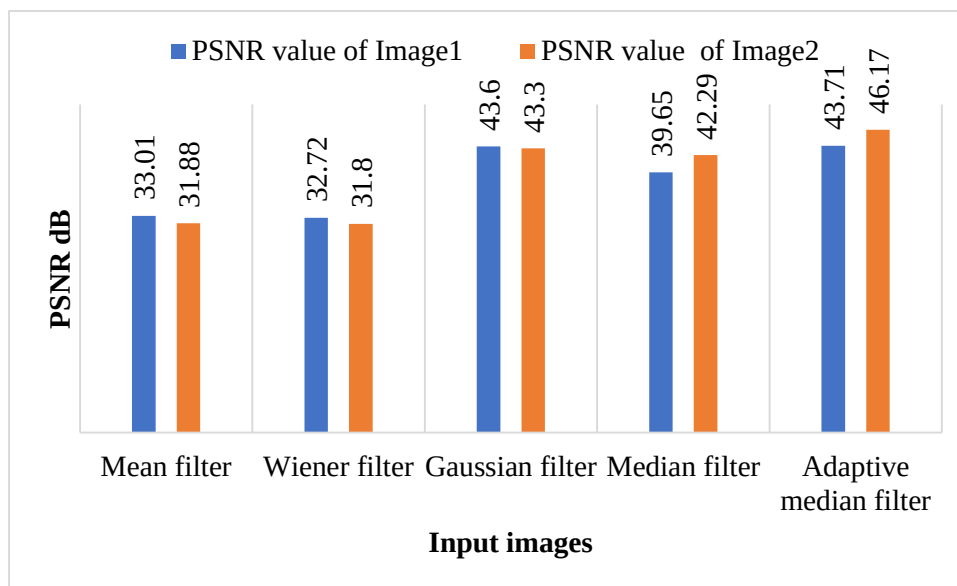


Figure 5: The comparison of PSNR values of denoised diabetic retinopathy images using various filters

From the chart, it is well understood that adaptive filtering performs better than other existing filters. Figure 4.3 gives a comparison chart of the PSNR values of our diabetic retinopathy images. Different denoising filters like mean filter, Wiener filter, Gaussian filter, median filter and adaptive median filter are used for comparison.



Article Title: Denoising of Diabetic Retinopathy Images Using Adaptive Median Filter

5 Conclusion

In this paper, we have considered techniques for preprocessing retinal fundus images. Preprocessing stage enhances the data of the retinal image based on the removal of noises, like Gaussian and impulse noise. This paper makes review on the five pre-processing methods – mean filter, median filter, gaussian filter, wiener filter and adaptive median filter, and discussed the principles, advantages, and disadvantages. It is observed that adaptive median filter is found to be better compared to other preprocessing methods because it has a higher PSNR value.

References

1. Ashish Bora; Siva Balasubramanian; Boris Babenko; Sunny Virmani; Subhashini Venugopalan; Akinori Mitani; Guilherme de Oliveira Marinho; J. Cuadros; P. Ruamviboonsuk; G. S. Corrado, L. Peng, Year: 2021, “Predicting the risk of developing diabetic retinopathy using deep learning”, The Lancet Digital Health, Articles, Vol: 3, no: 1, pp. e10-e19. ,
2. Martina Kropp; Olga Golubnitschaja; Alena Mazurakova; Lenka Koklesova; Nafiseh Sargheini; Trong-Tin Kevin Steve Vo; Eline de Clerck; Jiri Polivka Jr; Pavel Potuznik; Jiri Polivka; Ivana Stetkarova; Peter Kubatka; Gabriele Thumann, Year; 2023, “Diabetic retinopathy as the leading cause of blindness and early predictor of cascading complications—risks and mitigation”, EPMA Journal, Vol: 14, no: 1, pp. 21 – 42.
3. Dong An; Erandi Chandrasekhara; Dao-Yi Yu; Chandrakumar Balaratnasingam, Year: 2020, “Non-Proliferative Diabetic Retinopathy Is Characterized by Nonuniform Alterations of Peripapillary Capillary Networks”, Investigative Ophthalmology & Visual Science April 2020, Vol: 61, pp. 39.
4. Mukesh Chandra Arya; Ashish Semwal; PauriGarhwalwiener, Year: 2017, “Comparison on Average, Median and Wiener filter using Lung images”, International Research Journal of Engineering and Technology (IRJET), Vol: 04, no: 02, pp-ISSN: 2395-0072.
5. NasrulHumaimi Mahmood; Muhammad Rusydi Muhammad Razif; Mohammad Tajuddin; AsmNagoorGany, Year 2011,”Comparison between Median, Unsharp and Wiener filter and its effect on ultrasound stomach tissue image segmentation for Pyloric Stenosis”, International Journal of Applied Science and Technology, Vol: 1, no: 5, pp. 218 – 226.
6. Mukesh Chandra Arya; Ashish Semwal, Year 2017, “Comparison in Mean, Median and Wiener filter using Lung Images”, International Research Journal of Engineering and Technology, Vol: 04, no: 02, pp. 131 – 133.
7. Yudai Yamaguchi, Ichiro Yoshida and Yuki Kondo (2021), “Proposal of Edge-Preserving, Image Noise Reduction Filter for Using L2-Norm”, Eng. Proc. 2021, Vol: 11, pp. 27.



Article Title: Denoising of Diabetic Retinopathy Images Using Adaptive Median Filter

8. AkulaSuneetha; E. Srinivasa Reddy, Year 2021, “Robust Gaussian Noise Detection and Removal in Color Images using Modified Fuzzy Set Filter”, Journal of Intelligent Systems Vol: 30, no: 1, pp. 240 – 257.
9. Sandeep Chand Kumainy; MaheepSinghy; Krishan Kumar; Navjot Singh, Year 2018, “An efficient Gaussian Noise Reduction Technique for Noisy Images using optimized filter approach”, Conference: 2018 First International Conference on Secure Cyber Computing and Communication (ICSCCC).
10. Pyushi Singhal; Akhilesh Verma; Akash Garg, Year 2017, “A Study in Finding Effectiveness of Gaussian Blur Filter over Bilateral Filter in Natural Scenes for Graph Based Image Segmentation”, International Conference on Advanced Computing and Communication Systems (ICACCS -2015).
11. J. Seewig, Year 2005, “Linear and robust Gaussian regression filters”, Journal of Physics: Conference Series, Vol: 13, pp. 254 – 257.
12. Suman Shrestha, Year 2014, “Image denoising using new adaptive based median filter, Signal& Image Processing”, An International Journal (SIPIJ), Vol: 5, no: 4.