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Image Denoising Using Hybrid Filtering Techniques

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Abstract: Image is a key of digital data which is used in many studies and research work as dataset. These datasets are compromised due to distortion which is caused by the presence of noise. Occurrence of noise is found while capturing image, transmission of pictorial data over different networks, etc. An image can be corrupted due to various factors, among them Noise plays a vital role in image corruption and this noise can also exist individually with varying intensities of different noise factor or also as hybrid noise [i.e Combination of different noises], hence removal of noise becomes a main challenge in image processing. In general, the results of denoising affect the quality of the image processing approaches. The nature of the noise removal issue depends on the sort of the noise corrupting the image. The Salt and Pepper, Gaussian, Poisson and Speckle noise are the noises that usually affect the images. To restore these degraded images, many de-noising algorithm has been evolved and one among them are filtering techniques. In this research work, three filters are considered for denoising i.e. Weiner filter, Gaussian filter and Median filter. The current work is implemented on gray scale images and the evaluation of these algorithms is done by the measure of the PSNR and MSE values. In addition, we propose to use hybrid filter for denoising images that can be corrupted by individual or hybrid noise.

***Index Terms* - Image processing, Denoising, Hybrid, PSNR, MSE**

I. INTRODUCTION

The field of digital image processing entails the use of a computer to process digital images. An image's composition is made up of a limited number of pieces, each with its own placement and value. Picture elements, image elements, pels and pixels are all terms used to describe these elements. The term "pixel" is most commonly used to describe the components of a digital image. An image is a two-dimensional function that represents a measure of some attribute of an observed scene, such as brightness or colour. A projection of a three-dimensional scene into a two-dimensional projection plane is called an image. Gray level is a phrase that is frequently used to describe the intensity of monochrome images. Color images are created by combining discrete 2-D images. Image processing application involves various algorithms or processing levels [9, 10, 11, 13, 14]

Image restoration is a process for enhancing the appearance of an image. When exhibited, all natural photos have been corrupted in some way, whether in display mode, capture mode, or processing mode. The primary goal of restoration is to improve the quality of a digital image that has been deteriorated due to various types of noise or obscurity superimposed onto it. In image processing, noise removal is a crucial step. Various types of noise can make a picture illegible and clear, which can be a problem in many image processing applications. These include Gaussian noise, Salt & Pepper noise, Speckle and Poisson noise or a hybrid of the above mentioned noises.

Degradation is a process that works on a degradation function which in turn works on an input image along with an additional noise term. The corrupted image is given in the spatial domain by

$$g(x,y) = f(x,y) * h(x,y) + \eta(x,y)$$

If the degradation model is a linear position invariant process. Here the h(x, y) is spatial representation of degradation function and also the symbol * represents convolution. In frequency domain this equation can be written as

$$G(u,v) = F(u,v)H(u,v) + N(u,v) .$$

The Fourier Transform of the corresponding terms in the spatial domain are the terms in capital letters.

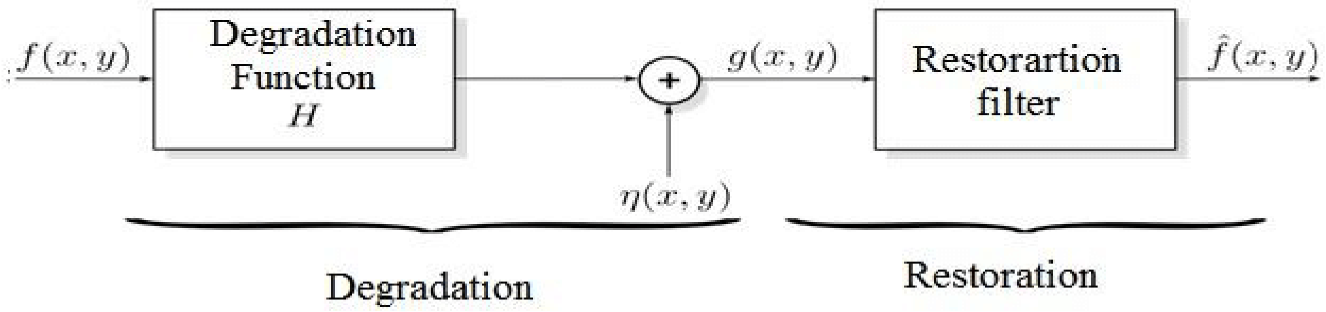

Figure 1: Restoration/ Degradation model

The noise has influenced the images up to some extent, that's unexplained selection in information: disturbances in image intensity that doesn't seem to be the ROI. If the noise could be removed then the image analysis is commonly simplified. In a comparable to seem to way, in science to liberate the fluids from the suspended pollution, the filters concept is applied by going through the suspended pollutions a layer of sand or charcoal. Engineers operating in signal processing have expanded the importance of the term filter to include operations which highlights the features of interest in images. Thus filters can attenuate the noises and improve the other features of the image. The images are rectified utilizing different filters like linear filters, non-linear filters, hybrid filters, decision- based filters, etc so as to recover the original properties or characteristics of the original image. In this work Median filter, Gaussian filter, Weiner filter and a hybrid of the mentioned filters are used.

II. LITERATURE SURVEY

[1]Bhausaheb Shinde Dnyandeo Mhaske, Machindra Patare A.R. Dani (2012) The outcomes given by Weiner Filter and Median Filter are better contrasted with different filters to eliminate Speckle noise, Gaussian noise and Poisson noise and the other noises present in an image. Weiner filter's benefit is it eliminates the additive noise and inverts the blurring simultaneously. Median filter's benefit is to eliminate outlines of an image without reducing the quality of the image.

[2] Rakesh M.R, Ajeya B, Mohan A.R (2013) Linear filters and non-linear filters are utilized to remove noise. The primary drawback of linear filters are they cannot totally remove the salt &pepper noise as they have a tendency to obscure the edges of an image while the nonlinear filters are mostly used to remove impulse noise .In this work ,the different filters used to denoise the colored images are examined .This method guarantees noise free and better quality of the images. The principle benefits of this median filter are the de-noising capability of the destroyed color component differences. But the fundamental downside is this method builds the computational intricacy.

[3]Medhavi Aggarwal, Ranjit Kaur and Beant Kaur (2014) The median filter is ideal contrasted with mean filter and adaptive filter to eliminate salt and pepper noise. The adaptive filter performs better than the mean filter but the drawback is it has additional time intricacy.

[4]Gurpinder Kaur Sivia, Amanpreet Kaur (2014) This paper presents Hybrid Filling-in technique for image restoration in which two filling-in procedures are utilized to reestablish the damaged image. In the first place, in the hybrid technique the distortion in the pixels is found out by executing Probabilistic Recovery Filling-in strategy . In this procedure, utilizing data from the surrounding pixels, the corrupted and missing pixels are established by low density of pixels and restored. Next the proposed filling-in technique is carried out to restore the noisy and distorted image where the GLCM is used to filter the properties of image. In the proposed work a thresholding strategy is created for restoration where the image can resist to the noise and any other distortion, and retain the property of the image in the original stage . After applying Probabilistic Recovery Filling-in technique, there are some distortions left which are eliminated to a large extent generally by carrying out proposed filling-in method. It tends to be presumed that the combination of these two strategies gives better outcomes.

[5]Abdalla Mohamed Hambal , Dr. Zhijun Pei, Faustini Libent Ishabailu(2015) There is a improved filter called hybrid median filter which preserves the corners and eliminates the impulse noise better than median filter. The benefits of hybrid median filter are it is easy to comprehend; it preserves the brightness difference and edges better than the median filter. The downside of hybrid median filter is only impulse noise can be denoised, the computational expense is high and it is a non-linear filter. Over rehashed application, the hybrid median filter does not inordinately smoothen the image details.

[6]Monika Kohli, Harmeet Kaur (2015)A comparative study of the proposed filter, Median filter and Adaptive median filter is done. The suggested Median filter is utilized to filter Impulse noise. The procured results indicate that the suggested strategy is much better than the standard median filter and the adaptive median filter. The Peak Signal to Noise Ratio (PSNR) is improved utilizing this strategy and the original features of the images are preserved.

[7]Ankita, Er. Lavina (2016) The proposed filter is a decision based filtering technique which combines the K-means and PCA procedure that is utilized for diminishing the undesirable noise henceforth gives better quality of images. The limitation of the hybrid filter is overcome by this proposed decision based filtering technique and the experimental results recommends better outcomes for decision based filtering technique contrasted with the hybrid filter.

[8]Reeturaj Mishra, Neetu Mittal, Sunil Kumar Khatri (2019) In this paper, a comparsion of Median filter, Weiner filter and Lucy Richardson filter is made. The evaluation parameters used are Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE) and Structural Similarity Index (SSIM) .From the trial results obtained, it very well may be inferred that Lucy Richardson algorithm is the best image restoration procedure which is assessed utilizing the parameters, such as PSNR, SSIM, and MSE. In an image with Gaussian blur noise model, every one of the three strategies has great outcomes however Lucy-Richardson algorithm ends up being the best. The Lucy-Richardson algorithm likewise ends up being a preferable strategy over the Weiner filter to eliminate the

Gaussian noise .Additionally the PSNR values acquired indicates that each algorithm has an insufficient margin with each other and also with the other evaluating parameters.

III. PROPOSED WORK

The proposed work discusses denoising technique's which involves using different filters to reduce the noise which can exist as individual and also as hybrid to obtain a better denoised image. The estimation of filtering techniques on the corrupted images is evaluated by Performance Parameters such as PSNR and MSE. Depending on the values obtained after filtering best filter to denoise the input image will be chosen, for a better filtering analysis hybrid of the above filters can be used.

Block Diagram:

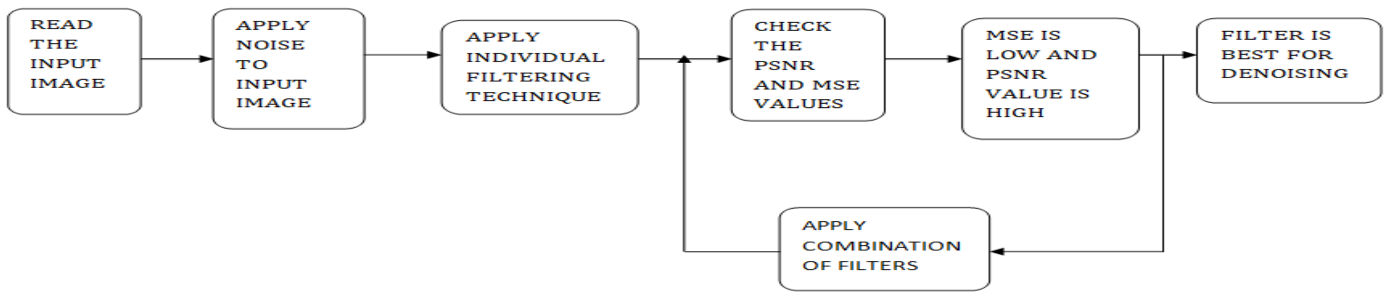

Figure 2: Block Diagram of the proposed method

The major steps of denoising algorithm on degraded images are as follows:
Step 1: Grayscale images are taken as input data set.
Step 2: Both individual and hybrid noise is applied externally to the input image for a better analysis.
Step 3: Analyze the type of noise and then apply denoising algorithm such as filtering techniques to eliminate noise and restore the image.
Step 4: Apply individual filters for denoising and also hybrid filters for better analyses.
Step 5: For choosing better filter among the applied filters, Performance Parameters such as MSE and PSNR are into consideration.
Step 6: If the value of MSE is low and PSNR is high then the filter applied is best for denoising. Incase if the values aren't matching the standard value set of MSE and PSNR, then different filtering techniques are applied to get better results, this procedure is repeated until the mentioned criteria is satisfied.
Step7: The best filtering technique is obtained for denoising the image.

IV. IMPLEMENTATION DETAILS

Images taken for consideration: Gray Scale image.
Supported Image format: TIFF, PNG, JPEG
Software used: MATLAB 2014 version [12].
Resolution of image: XResolution=72, YResolution=72
Base Noise: Gaussian Noise, Salt and Pepper Noise, Speckle Noise, Poisson Noise.
Base Filters: Gaussian Filter, Median Filter, Wiener Filter.
Performance Parameters taken into consideration are: PSNR and MSE

1) Mean Square Error: The MSE represents the cumulative squared error between the reconstructed image and the original image. It is a measure of the peak error. If the MSE is low it indicates that the error is low between the filtered image and the original images.

$$MSE = \frac{1}{mn}\sum_{0}^{m-1}\sum_{0}^{n-1}||f(i,j) - g(i,j)||^2 \qquad \text{Eq.1}$$

Where f represents the matrix data of our original image, g represents the matrix data of our degraded image, m represents the numbers of rows of pixels of the image and i represent the index of that row, n represents the number of columns of the pixels of the image and j represents the index of that column.

2) Peak signal-to-noise ratio: The Peak Signal to Noise Ratio (PSNR) is the ratio of the quality of the original image to the reconstructed image. If the PSNR is high it indicates that the quality of the filtered image is better.

$$PSNR = \frac{20log_{10}\ (MAX(f))}{\sqrt{MSE}}$$

Here MAX (f) is the maximum signal value that exists in the original image. The implementation of the work is useful for comparing noised and denoised images. Performance parameters such as MSE and PSNR values are useful to determine the best filtering technique to denoise the image which can be corrupted by various noises.

V. RESULTS AND ANALYSIS

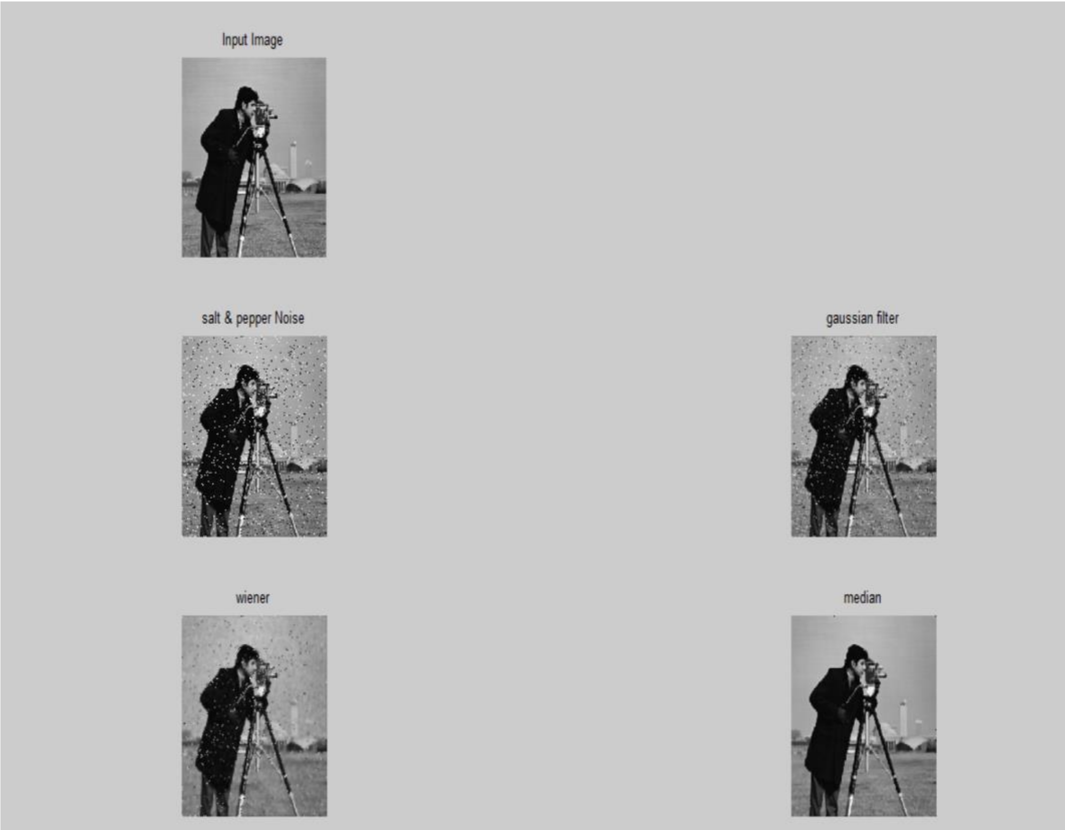

Fig 4.1.1: The input image (cameraman.tif) is noised with salt and pepper noise. Here the noisy image acts as an input image to the filters. Noise is added externally to note the changes. The noised image is denoised using Gaussian, wiener, median filter.

Fig 4.2.1: The input image (cameraman.tif) is noised with combination of all the 4 noises i.e (salt & pepper + Gaussian + Speckle + Poisson) noise. Here the noisy image acts as an input image to the filters. Noise is added externally to note the changes. The noised image is denoised using Gaussian, wiener, median filter.

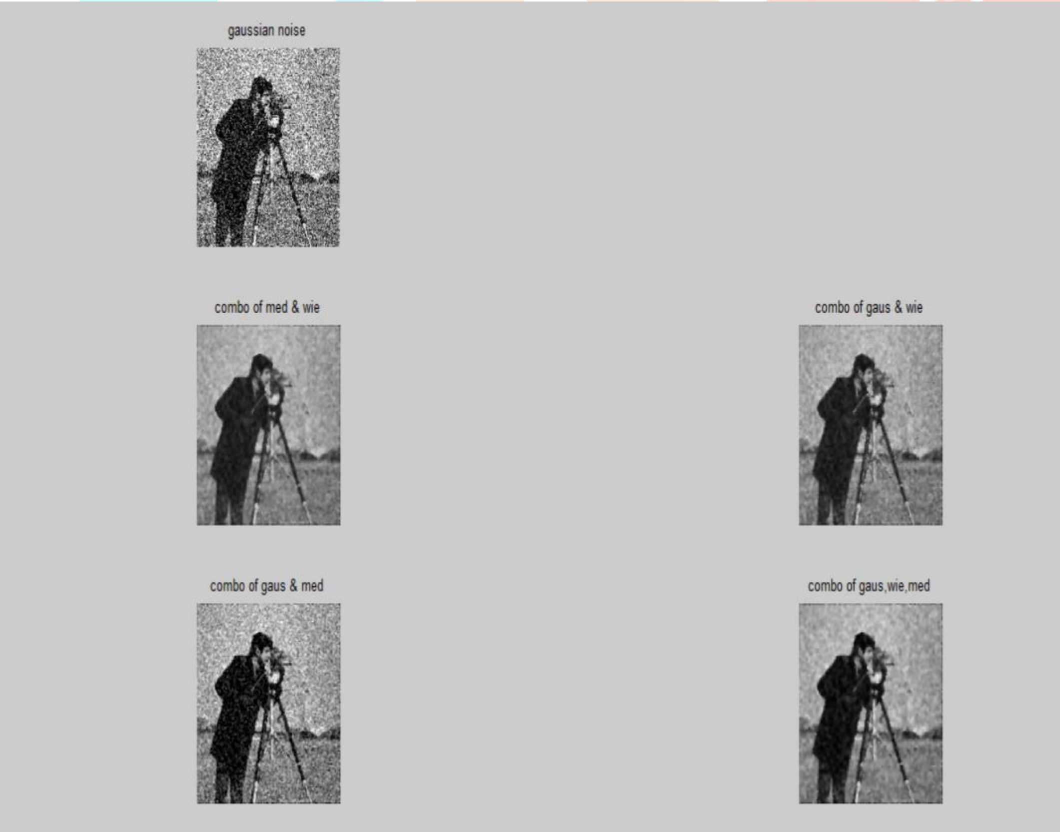

Fig 4.2.1: The input image (cameraman.tif) is noised with gaussian noise. Here the noisy image acts as an input image to the filters. Noise is added externally to note the changes. The noised image is denoised using combination of 2 and 3 filters i.e (Gaussian + wiener), (Gaussian + Median), (Median + Wiener), (Gaussian + Median + Wiener).

Fig 4.5.1: The input image (cameraman.tif) is noised with combination of all the 4 noises i.e (salt & pepper + Gaussian + Speckle + Poisson) noise. Here the noisy image acts as an input image to the filters. Noise is added externally to note the changes. The noised image is denoised using combination of 2 and 3 filters i.e (Gaussian + wiener), (Gaussian + Median), (Median + Wiener), (Gaussian + Median + Wiener).

TABLE 4.1: VALUES OF PSNR AND MSE OF INDIVIDUAL NOISE, INDIVIDUAL FILTER AND COMBINATION OF FILTER.

		Gaussian Filter	Wiener filter	Median filter	Median ,wiener filter	Gaussian, Wiener Filter	Gaussian, Median Filter	Gaussian, Median, wiener Filter
Salt & pepper noise	MSE	**26.29**	**40.60**	**17.10**	**39.73**	**43.29**	**22.89**	**31.37**
	PSNR	33.9662115	32.0798093	35.8358405	32.1732138	31.8013038	34.5675859	33.1994626
Gaussian Noise	MSE	**84.44**	**63.04**	**85.12**	**58.14**	**60.76**	**78.22**	**58.74**
	PSNR	28.8992965	30.1684464	28.8644764	30.5203671	30.3289460	29.2316033	30.4758126
Speckle Noise	MSE	**69.73**	**42.18**	**67.37**	**41.99**	**42.90**	**63.63**	**51.27**
	PSNR	29.7307949	31.9135316	29.8799482	31.9329691	31.8400246	30.1281016	31.0663920
Poisson Noise	MSE	**30.83**	**26.94**	**28.05**	**29.33**	**31.02**	**29.83**	**33.79**
	PSNR	33.2746468	33.8604836	33.6850048	33.4909916	33.2490644	33.4181088	32.8771379

TABLE 4.2: VALUES OF PSNR AND MSE OF COMBINATION OF TWO NOISES, INDIVIDUAL FILTER AND COMBINATION OF FILTER

Salt & pepper, Gaussian Noise	MSE	**84.40**	**66.49**	**84.74**	**63.56**	**66.78**	**80.49**	**61.45**
	PSNR	28.9013477	29.9370532	28.8838229	30.1330221	29.9183561	29.1071402	30.2795753
Salt & pepper, Speckle Noise	MSE	**73.26**	**54.87**	**69.17**	**52.00**	**55.31**	**66.42**	**54.17**
	PSNR	29.5160328	30.7716735	29.7657673	31.0043887	30.7368492	29.9418167	30.8274240
Salt & pepper, Poisson Noise	MSE	**40.63**	**42.85**	**30.76**	**41.44**	**45.44**	**31.91**	**35.16**
	PSNR	32.0766242	31.8448219	33.2855357	31.9906432	31.5904946	33.1253189	32.7043008
Gaussian, Speckle Noise	MSE	**95.11**	**78.97**	**105.94**	**76.67**	**77.62**	**100.16**	**88.14**
	PSNR	28.3823898	29.1899932	27.9140244	29.3185940	29.2649095	28.1578937	28.7130110
Gaussian, Poisson Noise	MSE	**85.87**	**65.47**	**87.07**	**60.19**	**62.80**	**79.80**	**60.80**
	PSNR	28.8262769	30.0042331	28.7659506	30.3695392	30.1850518	29.1446523	30.3259137
Speckle, Poisson Noise	MSE	**71.41**	**44.80**	**69.40**	**43.91**	**45.10**	**65.89**	**53.77**
	PSNR	29.6273758	31.6518857	29.7514112	31.7392974	31.6232802	29.9769100	30.8597264

TABLE 4.3: VALUES OF PSNR AND MSE OF COMBINATION OF THREE NOISES, INDIVIDUAL FILTER AND COMBINATION OF FILTER

Salt& pepper, Gaussian, Speckle Noise	MSE	**94.86**	**83.52**	**105.00**	**84.35**	**85.46**	**102.50**	**92.12**
	PSNR	28.3938409	28.9466927	27.9527264	28.9037572	28.8470173	28.0575413	28.5213171
Salt & pepper, Gaussian, Poisson Noise	MSE	**85.92**	**69.34**	**86.95**	**66.41**	**69.47**	**82.78**	**64.05**
	PSNR	28.8241058	29.7552106	28.7722050	29.9422467	29.7466078	28.9853690	30.0996450
Salt & pepper, Speckle, Poisson Noise	MSE	**96.13**	**82.13**	**107.16**	**80.35**	**81.16**	**101.47**	**89.68**
	PSNR	28.3361814	29.0196961	27.8646094	29.1148725	29.0713550	28.1012529	28.6380158
Gaussian Speckle, Poisson Noise	MSE	**50.94**	**45.54**	**40.75**	**42.81**	**46.68**	**38.59**	**37.87**
	PSNR	31.0943424	31.5807576	32.0639005	31.8498303	31.4737840	32.2998957	32.3814566
Salt & pepper, Gaussian, Speckle, Poisson Noise	MSE	**96.12**	**86.61**	**106.43**	**88.21**	**89.06**	**103.99**	**93.96**
	PSNR	28.3368467	28.7889253	27.8940120	28.7098364	28.6679175	27.9949763	28.4355156

Tables 4.1, 4.2, 4.3 contains the values of different MSE and PSNR values. First table has values of individual noise vs individual filter and combination of filters. Second table has values of combination of two noises vs individual filter and combination of filters. Third table has values of combination of three noises and all noises vs individual filter and combination of filters

This data is necessary to choose the best filter over the other filters. The outcomes of all filters employed for the noise are compared using MSE and PSNR calculations for all filtering methods. The obtained results are more informative and prove to be valuable for general analysis, as the noised image can be de-noised using the best filtering algorithm.

Table 4.4 consists of the best filtering algorithm for the type of noise present in an image.

TYPES OF NOISES	BEST FILTER
SALT & PEPPER	MEDIAN
GAUSSIAN	MEDIAN + WIENER
SPECKLE	MEDIAN + WIENER
POISSON	WEINER
SALT&PEPPER,GAUSSIAN	GAUSSIAN + MEDIAN + WIENER
SALT&PEPPER,SPECKLE	MEDIAN + WIENER
SALT&PEPPER,POISSON	MEDIAN
GAUSSIAN,SPECKLE	MEDIAN + WIENER
GAUSSIAN,POISSON	MEDIAN + WIENER
SPECKLE,POISSON	MEDIAN + WIENER
SALT&PEPPER,GAUSSIAN, SPECKLE	WIENER
SALT&PEPPER,GAUSSIAN, POISSON	GAUSSIAN + MEDIAN+ WIENER
SALT&PEPPER,SPECKLE, POISSON	MEDIAN + WIENER
GAUSSIAN,SPECKLE, POISSON	GAUSSIAN + MEDIAN + WIENER
SALT & PEPPER,GAUSSIAN, SPECKLE,POISSON	WIENER

V. CONCLUSIONS

In this work a set of Gray scale images are considered for noise removal. The dataset need not be corrupted by an individual noise; it can likewise be degraded by hybrid noise. Hence the study involves degrading the images by both individual and hybrid noise. Salt &Pepper, Gaussian, Speckle and Poisson noise and a hybrid of the mentioned noises are applied on the input images. The above input images are then denoised by applying various filtering methods like Median Filtering, Gaussian Filtering, Weiner Filtering and a hybrid of the mentioned filters to get precise outcomes. The filters mentioned in the above table prove to be the best to denoise the corrupted image. For performance analysis and assessment, parameters like PSNR (peak signal to Noise ratio) and MSE (Mean square Error) are considered. From this study a conclusion can be drawn that, the determination of filters for denoising the image depends on the of variety of noise which is liable for corruption and furthermore the performance parameter.

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