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# Assessment of Noise Filtering Techniques on Color Images

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**Abstract***:* Digital images are used in different applications such as military, medicine, geoscience, ecology, etc. The quality of the images ensures accuracy and precision of results. The raw digital images we work with everyday are generally stored, transmitted and progressed in many ways which results in addition of noise to the image. Raw digital images carries the different types of noises during capture, due to various formats of storage, transmission, resolution of cameras. These noises affects the content, quality and creates the loss of necessary details .So it is essential to eliminate these noises with preserving the fine details of image quality for processing. This paper focuses on reviewing and analysing existing noise reduction filters by implementing them on color images degraded by the noise. Performance of noise filters are evaluated to find the suitability.

**Keywords:** Filtering techniques, PSNR, MSE, Denoising

## I. INTRODUCTION

Usage of digital images are popular and attracted towards many areas and applications including vegetation, medicine, object detection etc. Data which are collected by cameras usually contains the noises and disturbances. Image noise is an unwanted fine points of the captured image. Noise is a random variation of the intensity of the image and is visible as part of the grains in the image. It can be caused due to the effects of the photonic nature of the basic physics of light or the thermal energy of heat within image sensors. Noise means that the pixels in the image display different intensity values instead of the actual pixel values that are obtained from the image. So processing the images with disturbances would cause severe affects in the results and quality of the output image. It is motivated to denoise the images before processing the images [6]-[9].

The denoising algorithm removes and reduces unwanted noise from the image. Removing the traces of noise by smoothing the entire image and discarding the areas which are very close to the contrast limits. But these methods can be vague and would be fine for low-contrast details. The common types of noise that are found in the images are gaussian noise, salt and pepper noise, Speckle noise shot noise, quantization noise, film grain, anisotropic noise etc. Every noises has distinguishable characteristics from others. There are numerous noise filters are available in the literature such as non-linear, linear, weiner, mean, min max, non adaptive etc. Classification of the noise removal filters are found in fig.1. Each filter technique has good efficiency on some types of noises. Finding the suitability would help to choose the correct technique for removing the noises. The rest of the paper is organized as literature survey in section II, methodology in section III, experimental results in section IV and section V concludes the paper.

## II. LITERATURE SURVEY

Wang Jianwei presents the noise removal algorithm based on pixel processing [1]. This algorithm not only works on gray scale image, but also can remove the noise in the color image based on three correlative components by call the algorithm from one to three times. In algorithm they have used the pixel operation on both gray scale and color images. Stefan et al [2] have used the Fuzzy Filter. The first sub filter computes the fuzzy distances between the color components of the central pixel and neighbourhood pixel. The second sub filter is used to correct the pixels where the color components differences are ruined much than they appear as outliers in the background. From this paper they conclude that this proposed method and wavelet based together will result in numerically and as well as visually.

Different filtering techniques for removing noise on color images are compared with results [3]. They have taken the filters like Linear Filter, Adaptive Filter, Non Linear Filter and Gaussian Filter and compared the results. They resulted that Median Filter technique works better in removing noise from the color images. Rui and Wei [4] the two algorithms maximum gradient algorithm and Euclidean gradient algorithm. Gradient peer group used to detect noise on color images and the proposed averaging algorithm will pick up the noise pixels and rebuild the pixels through the peer group averaging.

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In Paper[5] they have used mathematical based Morphology and Trimmed standard Median filter. Morphology namely Erosion and Dilation. This filter removes the noise from edge regions and inner regions of noisy images without distorting the features and color components.

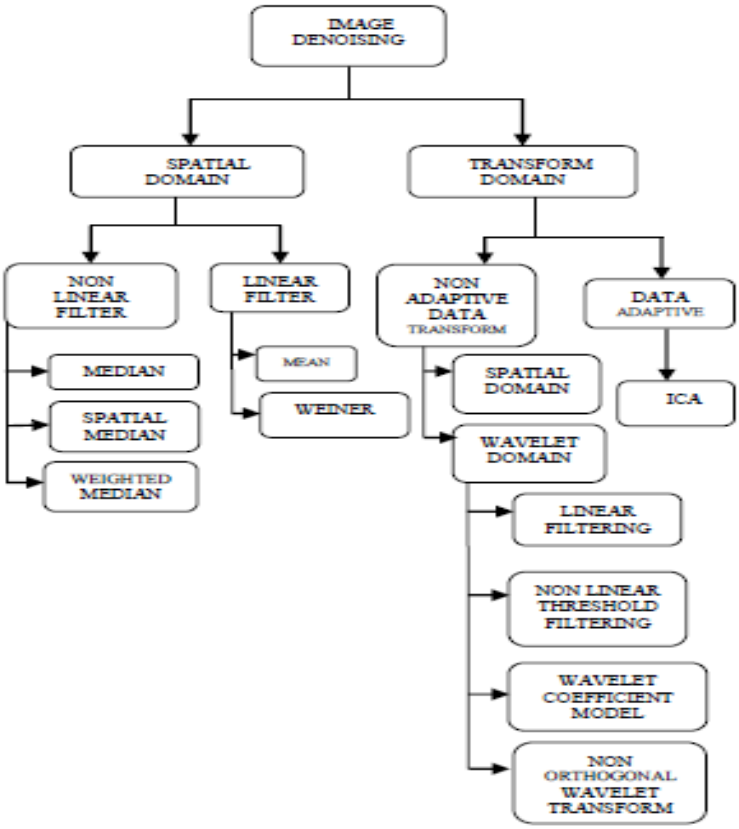


Fig.1 Classification of Noise Filters

## III. TYPES OF NOISES AND FILTERS

For this study and analysis three types of noises such as Gaussian noise, salt and pepper noise and speckle noise are discussed with their characteristics for better understanding. Fig.2 shows the types of noises.

### A. Gaussian Noise

It is also called as amplifier noise. The standard model of amplifier noise is additive, Gaussian, dependent on each pixel and dependent on signal strength, mainly caused by Johnson-Nyquist noise (thermal noise), including that coming from reset noise of capacitors ("kTC noise")[9]. It is white noise usually caused by random fluctuations in the signal. Amplifier noise is an important part of the image sensor noise, that is, the constant level of noise in the dark areas of the image. In Gaussian noise, every 40 to 4 pixels in the image will change from its original value (usually) by a small amount.

### B. Salt and Pepper Noise

Salt and pepper noise is also called impulse noise or spike noise or random noise or independent noise. In salt and pepper noise (little light and dark disturbance), the pixels in the image are very different in color or intensity as opposed to the surrounding pixels by a sudden sharp disturbance in the image signal. Generally this noise would only create disturbances in a few number of pixels in the image. When viewed, the image contains few dark dots and few white dots, hence the term salt and pepper noise [11]. This type of noise will create dark pixels in brighter portions and vice versa. Salt and Pepper noise can be produced due to dead pixels. This can sometimes occur with memory cell errors, with synchronization errors during image digitization or transmission. This type of noise can be caused by analog-to-digital converter errors and bit errors in transmission.

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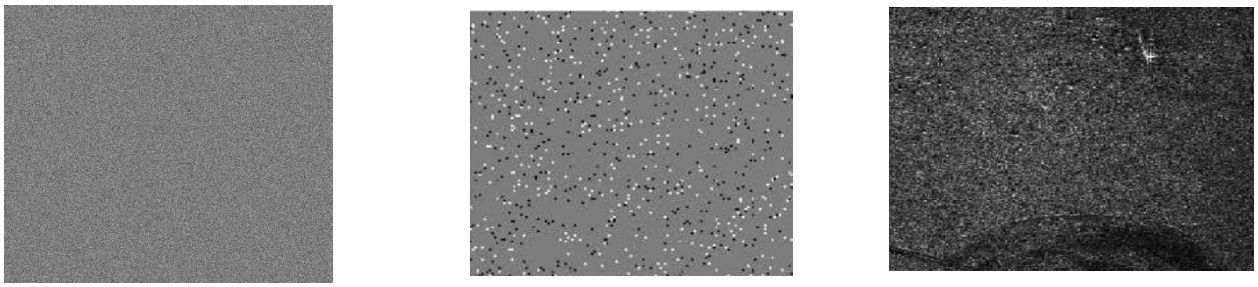
### C. SpeckleNoise

Speckle is a granular noise inherent in a degrades the quality of the active radar and the synthetic aperture radar (SAR) images[13]. Noisy noise in conventional radar results of random fluctuations in the return signal of an object not more than one image-processing element. It will increases the mean gray level of a local area. Speckle noise in SAR is generally more severe, causing difficulties for image interpretation. It is caused by coordinated processing of backscattered signals from multiple distributed targets. The SAR image is the average intensity estimate for the radar reflectance of the area being imaged. This type of noise can be modelled by random values multiplied by pixel values and hence it is also known as multiplicative noise. Multiplicative noise is a major problem in some radar applications.



Gaussian Noise Salt and Pepper Noise Speckle Noise

Fig.2 Types of noises

### Types of Filters

### A. Mode Filter

Mode Filter is used to remove noise from an image by replacing pixels with the most frequent pixel value selected from a certain window size. The mode filter is very effective in removing noise while not destroying sharp edges of an image. The mode filter is an edge- preserving the smoothing filter by taking the mode of empirical density. This can have applications in image processing such as image segmentation [14]. The mode filter is an image filter very similar to the mean filter and median filter. They process every pixel in an image. For a given pixel, the pixel value will be replaced by the mean or median over all pixels within a distance or away. The mean and median filter can be used in Image, it results in a smoothing of the image.

### B. NLM Filter

Weighted average of all the pixels in the image taken to find how similar these pixels are to the target pixel [2]. Compared to other known denoise techniques, non-local means add "method noise" that looks more like white noise is desirable because it is typically less obtrusive in the denoise product. Recently, non-local resources have been extended to other image processing applications, such as deinterlacing view interpolation and depth map regularization. The approach of filtering non-local means is based on estimating each pixel intensity from the information provided from the entire image, and thus takes advantage of the redundancy caused by the presence of similar patterns and features in the image. In this method, weighted average of the gray values of all pixels in the image produces the restored gray value of each pixel[6].

### C. Median Filter

It is a popular non-linear digital filtering technique that removes noises[15]. Median filtering is attracted towards various applications in digital image processing. Under certain conditions, edges are preserved while noise is removed. A much milder member of this family, such as one that chooses the closest of the neighboring values when the value of a pixel is outside of its neighborhood and leaves it otherwise, is sometimes preferred, especially in photographic applications. Median filtering is more better than averaging filter in that each output pixel is connected to an average of the pixel values in the neighborhood of the corresponding input pixel. The median is much less sensitive than the mean for extreme values (called outliers). Median filtering is consequently better able to remove these noise but retaining the fine details of the image.

## IV Methodology

In the algorithm, RGB color images are considered for input. Gaussian noise, Salt and Pepper noise and Speckle noise are added on the images and then the images are passed through the different filtering techniques that are Mode filter, NLM filter and Median filter. From the obtained filtered image the performance metrics Peak Signal Noise Ratio

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(PSNR) and Mean Square Error (MSE) are calculated and compared. The steps to be followed during processing depicted in the fig.3

**Algorithm**

Step 1**:-** Input color images
Step 2:- Add noise to the input image
Step 3:- Apply different filtering techniques to the image
Step 4:- Obtained filtered output image
Step 5:- Apply Performance Metrics to the obtained output image
Step 6:- Results obtained from the performance metrics

**Flow Diagram**

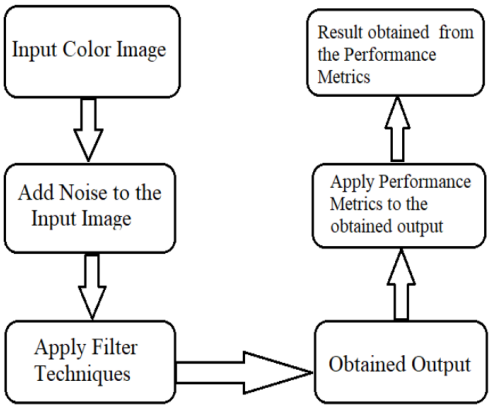


Fig. 3 Flow diagram of Noise filtering

## V Experimental Results

Experiments were carried out on different color images. Total number of images which are taken for experiments are 50.

A. **Gaussian Noise**

The input image is added with gaussian noise and filtered by mode, NLM and Median filters. The output of the filtered images are shown in Fig. 4

(a) Mode Filter Output (b) NLM Filter Output (c) Median Filter Output

Fig. 4 Output Filtered Images

**Performance Evaluation**

MSE and PSNR are calculated to compare the performance and is depicted in table 1. The **mean-square error** (**MSE**) and the peak signal-to-noise ratio (**PSNR**) are used to analyse the image quality. The higher value of **PSNR** high quality whereas the lower the value of **MSE**, the lower the error.

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Table 1. Performance evaluation of MSE and PSNR on Gaussian noise

| Filters | MSE | PSNR |
|---|---|---|
| **Mode** | 5.006 | 41.927 |
| **NLM** | 58.598 | 30.569 |
| **Median** | 79.309 | 29.138 |

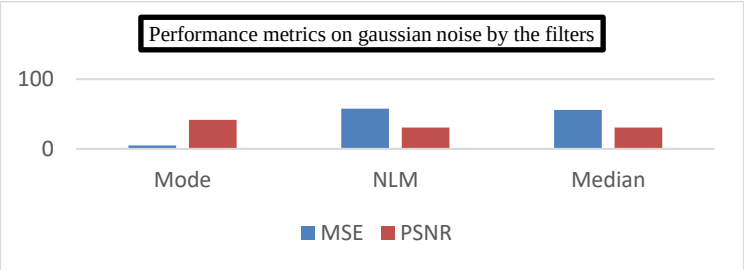
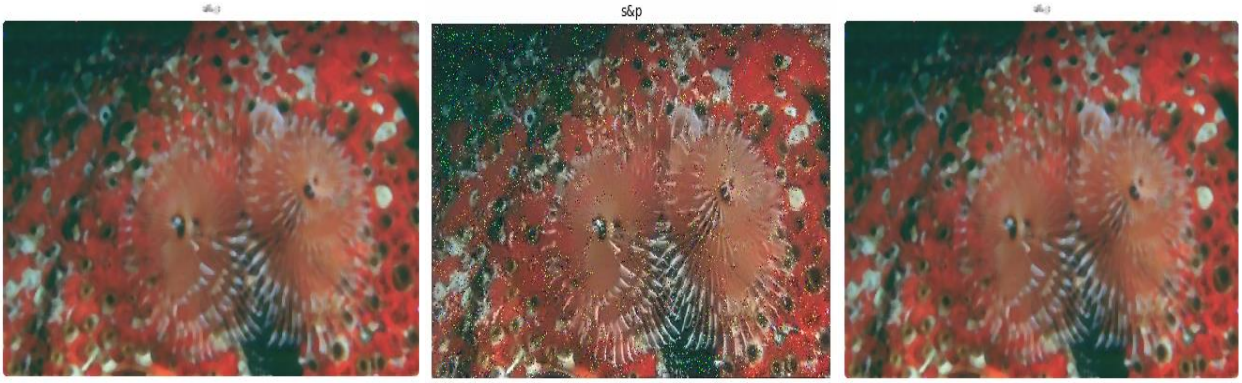



Fig. 5. Graphical representation of table 1

B. **Salt and Pepper Noise**

The input image is added with salt and pepper noise and filtered by mode, NLM and Median filters. The output of the filtered images are shown in Fig. 6. Table 2 shows the MSE and PSNR values for salt and pepper noise




(a) Mode Filter Output (b) NLM Filter Output (c) Median Filter Output

Fig. 6 Output filtered images

**Performance Evaluation**

Table 2. Performance evaluation of MSE and PSNR on Salt and Pepper noise

| Filters | MSE | PSNR |
|---|---|---|
| **Mode** | 3.845 | 42.318 |
| **NLM** | 26.526 | 34.010 |
| **Median** | 32.113 | 33.601 |

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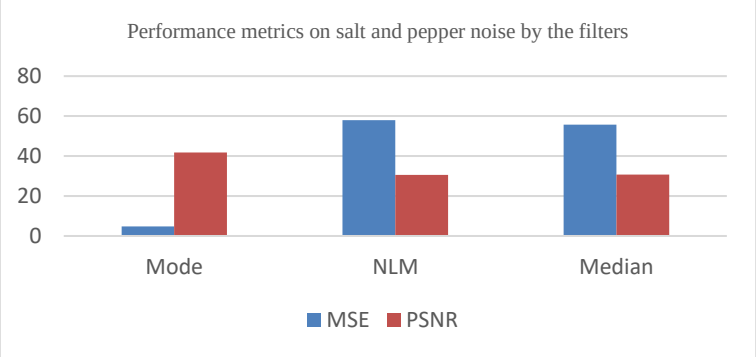


Fig. 7. Graphical representation of table 2

### C. Speckle Noise

The input image is added with salt and pepper noise and filtered by mode, NLM and Median filters. The output of the filtered images are shown in Fig. 8. Table 3 represents MSE and PSNR values for speckle noise

(a) Mode Filter Output (b) NLM Filter Output (c) Median Filter Output

Fig. 8 Output filtered images

**Performance Evaluation**

Table 3. Performance evaluation of MSE and PSNR on Speckle noise

| Filters | MSE | PSNR |
|---|---|---|
| **Mode** | 4.727 | 41.766 |
| **NLM** | 57.893 | 30.552 |
| **Median** | 55.687 | 30.714 |

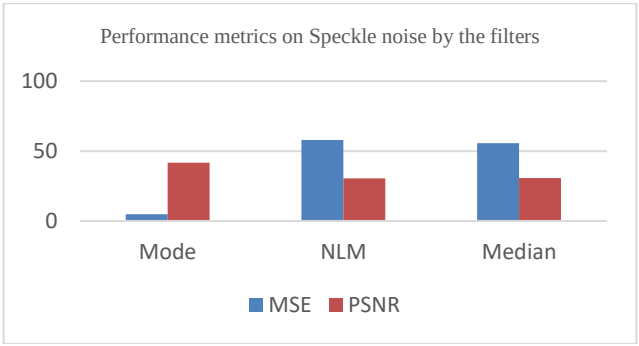


Fig. 9. Graphical representation of table 3

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## VI Conclusion

Different filtering techniques are analyzed for removing different noises in color image. Furthermore, from the compared results for these filtering techniques, the results obtained using mode filter technique ensures better noise removal and increased the quality of the image as well. The main advantages of mode filter are the removing the disturbances without degrading the image quality. Performance of different denoising algorithms is measured by using quantitative performance measures such as peak signal-to-noise ratio (PSNR), Mean Square Error (MSE). Since image denoising plays a crucial role in the field of digital image processing it is important to analyze enormous number of filtering techniques to obtain error-free and detailed results.

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