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Comparison of Denoising Filter Techniques

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***Abstract*— An Image has been often degraded by different types of noises when it is processed, compacted and stored which suppresses its feature and becomes a hindrance to image analysis and withdrawal of image features. Efficient noise suppressing and image de-noising technique is still a big challenge in image study and processing. Image Denoising refers to the improvement in a digital image that has been spoiled by noise so that the visual quality of an image is of high quality and used effectively for analysis. In spatial domain filtering techniques filters can undertake the denoising problems without changing the significant features of an image and gives us better results in restoring an image. Low image quality is a difficulty in the way to get effective feature extraction, study, recognition and measurements so this paper presents practical aspects of various types of filters that have been used for denoising. Experiment was performed on 12 test images in which different Gaussian noise levels were added and results has been compared by calculating peak signal-to-noise ratio (PSNR), mean squared error(MSE) to evaluate the performance of denoising techniques.**

***Index Terms*—PSNR, MSE, NLM**

I. INTRODUCTION

In images, noise is the undesirable information that degrades the image quality. An Image has been often corrupted by different kinds of noises when they are processed, compressed and stored which degrades its quality and becomes an obstacle to image analysis and extraction of image features. The original meaning of noise was unwanted sound, unwanted electrical fluctuations in signals caused noise. Noise has low as well as high frequency components. The distortions of images by noise are common during its acquisition, processing, compression, transmission etc. Noise is an undesirable product of image that adds extraneous information and represents unwanted information which degrades image quality and is not a part of image.

First of all standard images are selected and Gaussian noise has been added within these images. After adding the Gaussian noise on various extents, then these images are converted to digital signals and denoising technique was applied to these signals using various denoising filters. After the denoising technique is applied then PSNR [7] and MSE [13] are calculated on all the images using various filters and then the results are compared of all filters. Median filter [13] is a non linear filtering method used for noise reduction in an image and widely used for its simple algorithm. Median filter provides excellent noise reduction capabilities and less blurred images as compared to linear smoothing filters. But in this method, some detailed information such as edges, and texture in the images are lost and this disadvantage will be more apparent as the filter window size increases. NLM [9] technology reproduces even a very low quality image after the denoising technique is applied on the image. In NLM technique, denoising is done by taking the average of all pixels and is on the assumption that image is pixels repeat itself. Bilateral filter [12] works as the combination of range and domain filtering. Bilateral filters work in the range of the image what other filters do in the domain of the image. There are various noises which can be added to the images as sale petter noise, speckle noise but in this paper Gaussian noise is being used and is added in the images and then PSNR and MSE values are calculated and after this the noised images are gone through the process of denoising and then again PSNR and MSE values are calculated by using different noise levels and using the three filters namely non local means filter, bilateral filter and median filter. The PSNR and MSE values of these filters had been compared and corresponding results are analyzed.

In this article we introduces a brief description of image denoising. It presents overview about denoising filters with an example. The second section of this paper describes the different type of noises and its source, image denoising and types of filters. In the third section gaussian noise is added to the image and then this image is denoised using NLM and bilateral filters. In the next section discussion and conclusion by using various denoising filters i.e. non-local mean filter and bilateral filter on different images by adding different type of noises and then in the last step the future avenue of all the work done has been elaborated in this paper.

II. NOISE AND FILTERS

A. Gaussian Noise

Gaussian noise is an additive noise having a probability density function (PDF) equal to that of the normal distribution in other words we called Gaussian distribution and the values that the Gaussian noise can take are Gaussian distributed. The PDF of Gaussian noise is given by [4]

$$p(z) = \frac{1}{\sqrt{2\pi}\sigma} e^{-(Z-\bar{Z})^2/2\sigma^2}$$

B. Median Filter

Median Filter is non linear filter which is used to remove noise from digital images. Median filters provides valuable results as they produce less blurring images.

C. Bilateral Filter

In Bilateral filter both domain and range of images are combined. It is a type of non linear filter and it works to procure edges of images. The concept used in this filter is that

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it do the work in range of the image which other filters do in the domain of the filters.

E. Non Local Means Filter

The most efficient technique is the non local means technique (NLM). Inspite of using single pixel technology it uses patch based technique and hence enhances the edges and other quality of image. In this, concept of two windows is used, one window is called search window and other is called similarity window.

III. PERFORMANCE VARIABLES

To evaluate the performance of denoising filters we used performance variables as peak signal to noise ratio and mean square error.

MSE (Mean Square Error) represents the error between the original image and restored image. It is the sum of all squared value differences between the original and restored image divided by image size. The quality of denoised image is better if it has the lower MSE value.

$$MSE = \sum_{M,N} \frac{(g(m,n) - f(m,n))^2}{M \times N}$$

PSNR (Peak signal-to-noise ratio): The PSNR is the peak signal-to-noise ratio, in decibels, between two images. This PSNR ratio is used as a quality measurement between the original image and restored image. The quality of denoised image is better if it has the higher PSNR value.

PSNR is computed as follows:

$$PSNR = 10log_{10}\left[\frac{255 \times 255}{MSE}\right]$$

IV. EXPERIMENTAL RESULTS AND DISCUSSIONS

In this section performance of denoising filters had been analyzed. All the filters taken were compared on the basis of performance variables taken in this i.e peak signal to noise ratio and mean square error. The noise levels added to different images were varied to different values as

Fig. 1, Jetplane image

Fig. 2, Jetplane image after adding noise

Fig. 3, Denoised Result of Median filter

Fig. 4, Denoised Result of Bilateral filter

Fig. 5, Denoised Result of Non Local Means filter

Fig. 6, Goldhill image

Fig. 7, Goldhill image after adding noise

Fig. 8, Denoised Result of Median filter

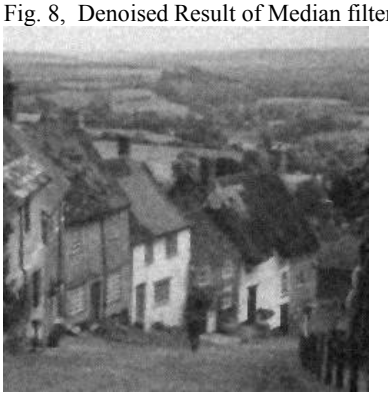

Fig. 9, Denoised Result of Bilateral filter

Fig. 10, Denoised Result of Non Local Means filter

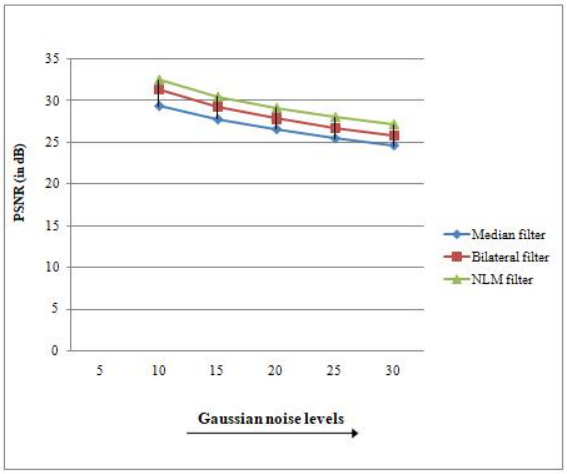

Fig. 11, Graphical representation of average PSNR of different denoising filters

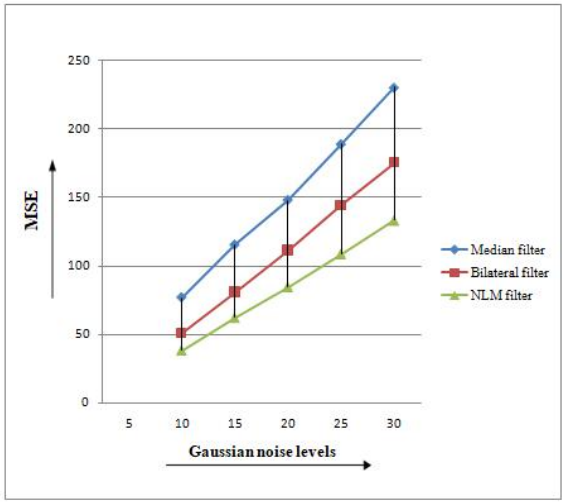

Fig. 12, Graphical representation of average MSE of different denoising filters

V. CONCLUSION

Median filter suppress the noise and widely used for its simple algorithm. The denoised images still contain noise and also some detailed information such as edges in the images are lost.

Bilateral filter performs better than median filter. It preserves the edges but at higher noise levels, it still contains some amount of noise and restored image is over smoothed. Average PSNR of bilateral filter is higher than that of median filter and the average MSE of bilateral filter is lower than the median filter. This shows that performance of bilateral filter is better than median filter.Non-local means filter perform better than all the filters. It preserves the edges and also restored the better quality image in its visual appearance so we find that NL-means filter preserves the more significant details, texture, edges of an original image from the noisy image. Based on all the experimental results it can be seen from tables, graphs and images the NL-means filter has the higher PSNR value and the lower MSE value provides better performance in both PSNR and visual quality of an image out of all the three filters.

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