A Survey on Noise Reduction in Images

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ABSTRACT
Image processing is processing of images using mathematical operations by using any form of signal processing for which the input is an image such as a photograph or video frame and the output may be either an image or a set of some parameters related to the image. Images quality is often degraded by noises. Noise can occur during image capture, transmission or by film grain in it etc. Noise removal is an important task in image processing. Developing an efficient method of removing noise from digital images before processing them is an essential process in image processing to achieve image enhancement. In the field of image noise reduction, several linear and nonlinear filtering methods have been proposed and various other algorithms were given to improve quality of different images. It is a challenging problem to remove mixed noise in color images. Generally, some image denoising filters can reduce either additive or impulse noise, but they fail to remove both. The bilateral filtering action can simultaneously remove impulsive and additive noise while preserving edge structures. Similarly, Image edge detection is a process of locating the edge of an image which is important in finding the approximate absolute gradient magnitude in gray scale image. The results of the noise removal have a strong impact on the quality of the image processing technique.

Keywords
Image processing, Linear Filter, Non-Linear Filter, Image denoising, Additive Noise, Impulse Noise, Average Filter, Vector Median Filter, Bilateral Filter, Image enhancement, MSE, PSNR.

1. INTRODUCTION
Digital image processing is the use of computer algorithms to perform image processing on digital images especially in order to improve its quality. The result of errors in the image acquisition process is called noise, which results in pixels value that do not reflect the true intensities of the real scene. All recording devices, both analogue and digital have some traits which make them susceptible to noise. Depending on how the image is created, some of the ways in which noise is introduced in an image are –
1. If the image is scanned from a photograph made on film, the "film grain" is a source of noise.
2. Noise can also be the result of damage to the film, or be introduced by the scanner itself.
3. The electronic transmission of image data can introduce noise.
4. Images are mostly affected by mixed noise which is a combination of impulsive noise and additive noise. [1]
The fundamental problems of image processing are to reduce noise from a digitized image. Noise Reduction is the term used for the process of eliminating noise from an image (or from a signal). In this process, information about the type of noise present in the original image plays a significant role. But despite the phenomenal recent progress in the quality of de-noising algorithms, the current research has not yet reached the lower bound on the mean squared error of the de-noised result. However, Edge Detection from images is one of the most important concerns in digital image processing and with development in technology, edge detection has been greatly benefited and new avenues for research have opened up. The purpose of edge detection is to reduce the amount of data in an image, while preserving its structural properties to be used for further image processing. But it is difficult to implement edge detection in noisy images, since both the edges and the noise contain high-frequency content and attempts to reduce the noise result in distorted and blurred edges. [2]
Reducing the noise and blurring and increasing the contrast range could enhance the image. Image denoising improves the quality of images for human viewing. [3]

2. LITERATURE REVIEW
2.1 Types of Noise
Here, we classify some standard noise for eliminating noise in color images-[1]

2.1.1 Salt and Pepper Noise
(Impulse noise, Random noise, Independent noise) - In this, pixels in the image are very different in intensity and color unlike their surrounding pixels. This type of noise is caused by dead pixels or analog-to-digital converter errors and bit errors in transmission. Image containing this type of noise will have dark pixels in bright regions and white pixels in dark regions.

2.1.2 Speckle Noise
(Multiplicative noise) - It is modeled by random values multiplied by pixel values. This type of noise is caused by signals from elementary scatters, the gravity capillary ripples and manifests as a pedestal image, beneath the image of the sea waves.

2.1.3 Amplifier Noise
(Gaussian noise) – This type of noise is an idealized form of white noise, which is caused by random variations in the signal. In Gaussian noise, each pixel in the image will be changed from its original value by a small amount.

2.1.4 Shot Noise
It has a root mean square value proportional to the square root of the image intensity and the noises at different pixels are independent of one another. Photon shot noise is the dominant noise in the lighter parts of an image from an image sense that caused by statistical quantum fluctuations i.e. variations in the number of photons sensed at a given exposure level.

3. VARIOUS TECHNIQUES FOR REMOVING NOISE FROM IMAGES

3.0.1 Salt and Pepper Noise Removal [1]

To improve contrast in image, adaptive histogram equalization technique is performed on the input image. Then, to improve the quality of an image, adaptive contrast enhancement is applied. After that, contrast stretching is done for improving the contrast and filtering is used for image enhancement. Finally, output is noise free image.

3.0.2 Mixed Noise Removal [3]

Filters are required for removing noise before processing. There are two types of filters:

Linear Filters

Averaging or Gaussian filters are appropriate for this purpose. This type of filters tends to blur sharp edges, destroy lines and other fine image details and performed poorly in the presence of signal dependent noise.

Non-Linear Filters

Here, noise can be removed without identifying it exclusively. It employs a low-pass filtering on the assumption that noise always occupies higher region of spectrum frequency.

4. FILTERS USED IN DENOISING

4.0.1 Mean Filter (MF)

Mean Filter is a simple linear filter, intuitive and easy to implement method of smoothing images i.e. it reduces the amount of intensity variation between one pixel and the next pixel.

4.0.2 Standard Median Filter (SMF) –

Median filter is the non-linear filter which changes the image intensity average value if the spatial noise distribution in the image is not symmetrical within the window.

4.0.3 Adaptive Wiener Filter (AWF) –

Adaptive Wiener Filter changes its behavior based on the statistical characteristics of the image present inside the filter window. Mean and variance are two important statistical measures which are using in adaptive filters designing.

4.0.4 Gaussian Filter (GF) –

Gaussian low pass filter is the filter which give impulse responsive and Gaussian filters are invented to give no overshoot to a step function input while minimizing the rise and fall time.

4.0.5 Adaptive Median Filter (AMF) –

The Adaptive Median Filter is designed to remove the problems faced with the Standard Median Filter. The basic difference among both the filters is that in the Adaptive Median Filter, the size of the window surrounding each pixel is variable. This fluctuation depends on the median of the pixels in the present window. [1]

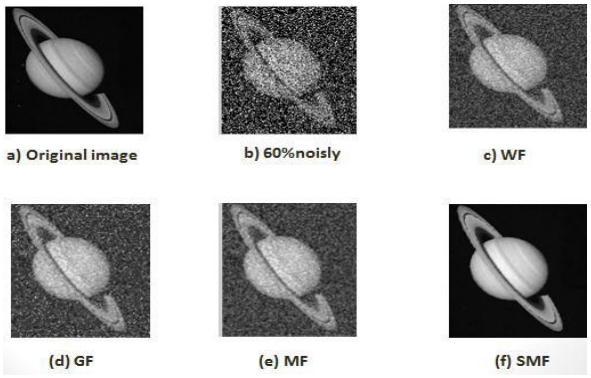


Fig 1: Comparison of different filters result by an image

5. VARIOUS PROPOSED ALGORITHM

Various algorithms were proposed for different types of images focusing on image enhancement.

Few of them are -

1. The Canny Edge Detection Algorithm
2. Noise Removal in Images in the Non Sub sampled Contourlet Transform Domain Using Orthogonal Matching Pursuit
3. Noise Reduction of Enhanced Images Using Dual Tree Complex Wavelet Transform and Shrinkage Filter
4. Image Denoising based on Spatial/Wavelet Filter using Hybrid Thresholding Function
5. Image Enhancement with Noise Reduction in Spatial Domain

5.1 The Canny Edge Detection Algorithm

This algorithm runs in 5 steps:

1. **Smoothing**: Blurring of the image to remove noise.
2. **Finding gradients:** The edges should be marked where the gradients of the image has large magnitudes.
3. **Non-maximum suppression**: Only local maxima should be marked as edges.
4. **Double thresholding:** Potential edges are determined by thresholding.
5. **Edge tracking by hysteresis:** Final edges are determined by suppressing all edges that are not connected to a very certain edge.[1]

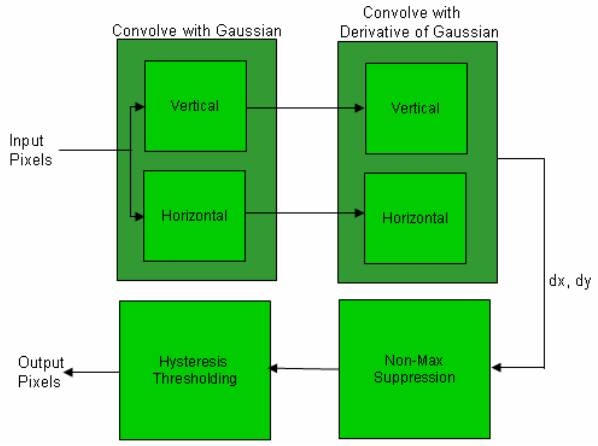


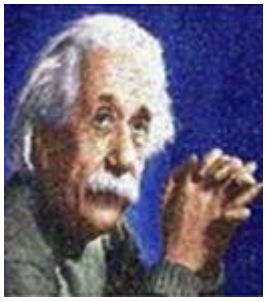
Fig 2: Canny Edge Detection Algorithm Process

5.2 Image Enhancement with Noise Reduction in Spatial Domain

In many situations, images are mostly affected by mixed noise which is a combination of impulsive noise and additive noise.

Mixed noise is the combination of additive noise and impulse noise. It is caused due to faults in camera sensors, exceptional memory locations in hardware, transmission of images in noisy channels, and atmospheric disturbances. The proposed method, average filter and vector median filter and bilateral filter are implemented and compared.

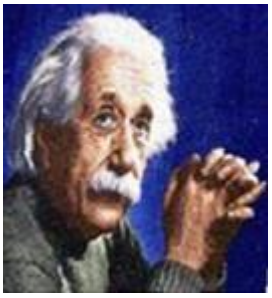
Consider the following example of a noisy image -



NOISY IMAGE

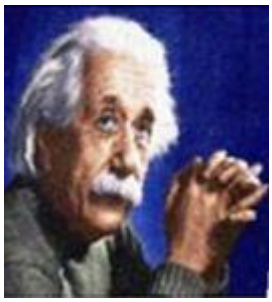
Use of Filters:

i. **Average Filter (AF)** Average filter is the simplest type of filter to remove noise from image. In this technique, each pixel is replaced by arithmetic mean of neighboring pixels. This can remove light noise but introduces blurriness in image.



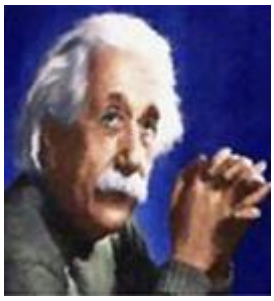
(AF)

ii. Vector Median Filter (VMF) VMF was proposed to remove salt and pepper noise. It acts in a way that the windows set on each pixel of the image and the value of color components of red, green, and blue in the central pixel of the window are replaced with color components of one of pixels which is in the window.



(VMF)

iii. Bilateral Filter (BF) The bilateral filter is a non-linear technique that can blur an image while respecting strong edges, by means of a nonlinear combination of nearby image values. The method is non-iterative, local, and simple.



(BF)

Thus, **Bilateral filtering method** is good efficient method for removing of mixed noise from color images and it is implemented.[3]

Table 1. Quality Measures of Einstein's Image (256*256)

PARAMETERS	AF	VMF	BF
MSE- Mean Squared Error	7.331	6.944	3.072
PSNR- Peak Signal to Noise Ratio	30.827	31.288	38.384

Table 2. Review on various proposed algorithms [1][2][3][4]

YEAR	AUTHOR	TITLE	METHODOLOGY	ADVANTAGES	LIMITATIONS
2015	Tarik Ahmad Lone, Showkat Hassan Malik	A Literature Survey of Image Denoising Techniques in the Spatial Domain	Focusing on spatial domain denoising techniques.	Edge preservation and robustness against large noise deviations. Smoothes local variations at the cost of blurring.	Requires information about the spectrum of the noise and the original signal. Removal of important image details, jitter and streaking is difficult.
2015	Divya V, Dr. Sasikumar M	Noise Removal in Images in the Non Subsampled Contourlet Transform Domain using Orthogonal Matching Pursuit	Image is first transformed to the Non Subsampled Contourlet Transform (NSCT) domain and then Support Vector Machine (SVM) is used for classifying noisy pixels from the edge related ones.	Achieves a good visual quality with very less quantity of disturbing artifacts, while analytically ensuring the same in terms of qualitative metrics, with no information on the noise.	There is a challenge to take the initial estimate to the Orthogonal Matching Pursuit (OMP) algorithm. For enabling the method in online processing, computation and time optimization techniques can be sought.
2015	S.Shyam Prasad, R.Priya	Image Enhancement with Noise Reduction in Spatial Domain	Focussing on modified bilateral filtering method, when compared to average filter and vector median filter.	The bilateral filtering action can simultaneously remove impulsive and additive noise while preserving edge structures.	
2015	Vinod Sharma, Deepika Bansal, Renu Bagoria	A Review on Digital Image Enhancement by Noise Removal	Focussing on image noise removal by the use of different filters	Various filters are better in removing the noise.	Unable to remove all types of noise from an image

5.3 Image Quality Measures

Measurement of image quality is important for many image processing applications. Image quality assessment is closely related to image similarity assessment in which quality is based on the differences (or similarity) between a degraded image and the original, unmodified image. [2]

Quality has been measured in terms of metrics such as –

1. Mean Squared Error (MSE)
2. Peak Signal to Noise Ratio (PSNR)

5.3.1 Mean Squared Error (MSE)

It stands for the mean squared difference between the original image and distorted image.

5.3.2 Peak Signal to Noise Ratio (PSNR)

PSNR is a classical index defined as the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation.

6. CONCLUSION

In this paper we discussed different types of noises present in the images along with few noise removal techniques. Thus, we can now say that noise is the extra bits present in the image that make the visual of the image low. Different types of noise have different effect on the image. We can identify the type of noise from the image itself and many filters can be applied on the image to remove the noise from the image. To overcome the disadvantages that the average filter and vector median filter cannot remove both impulsive and additive

noise, a modified bilateral filtering method is used. We also have a comparative study of all the filters and we have results that which filter is better in removing the noise. In future, we can develop software that applies all the filters on a single image to remove all types of noise from that image and hence, make the image look good.

7. ACKNOWLEDGEMENT

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8. REFERENCES

[1] Vinod Sharma, Deepika Bansal, "A review on digital image enhancement by noise removal", IJIRSET, vol.4, may 2015

[2] Divya, Dr.Sasikumar, "Noise Removal in Images in the None Subsampled Contourlet Transform DomainUsing Orthogonal Matching Pursuit", IJIRCCE, vol.3, June 2015.

[3] Shyam Prasad, R.Priya, "Image enhancement with noise reduction in spatial domain", IJARCSSE, vol.5, Jan 2015.

[4] Tariq Ahmad Lone, Showkat Hassan Malik," A Literature Survey of Image Denoising Techniques in the Spatial Domain", IJARCSSE, vol.5, Feb 2015.