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An Efficient Image Denoising Technique Using Hybrid Filter Approach

Surbhi Madaan*, *Arun Bhatia***

**ECE, Kurukshetra University, Haryana, INDIA*

***Lecturer of ECE, Kurukshetra University, Haryana, INDIA*

***Abstract*— In today's emergent digital world, Digital Images had an important role in daily routine applications such as Magnetic Resonance Imaging, Satellite TV along with an areas of research and technology including Geographical Information System. Noise is unnecessary signal that hinders with the original image and degrades the visual quality of original image. The major cause of noise in digital images is imperfect instruments, problem with data acquisition process, obstruction natural phenomena, broadcast and compression.**

Image denoising is a procedure in digital image processing for the removal of noise, which can distort an image through its acquisition or transmission, while retaining its visual quality. Thus; image denoising is the required and foremost step for image investigation. So, it is necessary to depute some effective image denoising methods to avoid this type of corruption from digital images. In this paper we review image denoising technique using various types of hybrid filters approach. Different types of filters are Weiner filter, Adaptive Weiner filter, Mean filter etc. These filters are used for removal of different types of noises which occurs due to transmission and reception, imperfect instruments etc.

***Index Terms*— Adaptive Filter, Denoising, Mean Filter, Noise, Weiner Filter.**

I. INTRODUCTION

Images are produced to display useful information or details. Due to flaws in the imaging and capturing process, however, the recorded image always represents a corrupted version of the original scene. The undoing of these imperfections is critical to many of the successive image processing functions. There exists a wide range of degradations, which must be taken into consideration, for example noise, geometrical degradations, illumination and color imperfections and blur.[7]

Digital images play a very important role both in applications such as television magnetic resonance imaging computer tomography as well as in area of science and technology such as geographical information system and astronomy. Sets of data poised by image sensors and other devices are generally corrupted by noise .Also noise can be introduced due to transmission errors and compression. Hence denoising is a necessary and first step to be performed before image data is analyzed and processed. Here various effective methods have been studied. An effective denoising technique must be applied to compensate for such data corruption.[8]

Image Denoising

Denoising an image is a principle task for correcting defects produced during the acquisition process of a real world scene and its replica on a display, due to physical and technological limitations. It can also be useful as a pre-processing stage in order to refine the results of higher level applications. The problem of removing the noise of an image while maintaining its main characteristics (edges, textures, colors, contrast, etc.) has been extensively investigated over the last two decades and various types of approaches have been developed.[5]

Block Diagram of Image Denoising:

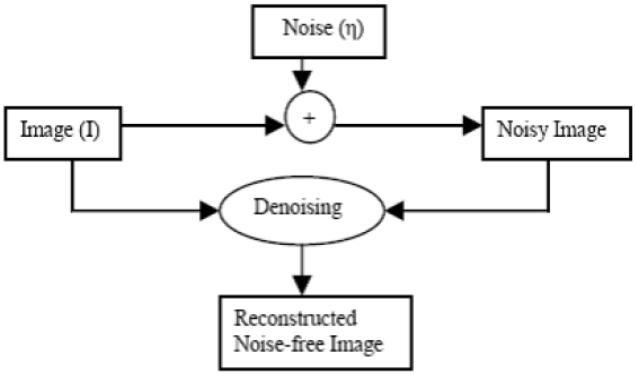

Fig.1 Block Diagram Of Image Denoising

Types of Noises

- **Gaussian Noise**

Gaussian noise is evenly spread over the signal. Each pixel in noisy image is the addition of true pixel value and a erratic gaussian distributed noise value. This noise has a probability density function of the normal distribution. It is also known as Gaussian distribution. It is a main part of the read noise of an image sensor that is of the constant level of noise in the dark areas of the image.[14]

- **Salt-and-Pepper**

The salt-and-pepper noise is also recognized as shot noise, impulse noise or spike noise. An image containing salt-and pepper noise will have dark pixels in bright portions and bright pixels in dark portions. It can be created by various factors such as dead pixels,

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analog-to-digital converter errors and bit errors in transmission. It has only two possible values- a high value and a low value. The likelihood of each is typically less than 0.1.[15]

- **Speckle Noise**

Speckle noise is a granular noise that naturally exists and degrades the quality of the active radar and synthetic aperture radar (SAR) images. Speckle noise in prevailing radar results from irregular fluctuations in the return signal from an object that is no larger than a single image-processing element. It increases the mean grey level of a local area. It is a multiplicative noise. The source of speckle noise is random interference between the coherent returns [15].

Image Restoration

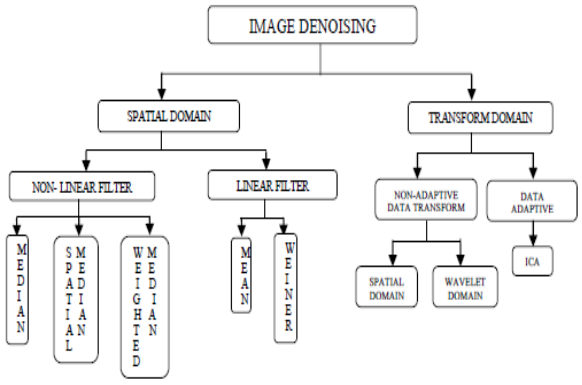
Image Restoration means a group of methods or techniques that helps to remove or reduce the degradations that happened while the digital image was being achieved. All natural images when displayed have gone through some sort of degradation:

- The degradation may take place during display mode
- The degradation may happen when camera is in the acquisition mode, or
- Through processing technique degradations may also takes place.

The degradations may be due to

- The degradation may take place due to sensor noise
- The degradations may Blur due to camera misfocus
- The degradation may occur due to relative object-camera motion

Classification of Image Denoising Techniques:



Spatial Filtering

It is a conventional method to remove noise from image where spatial filters are used. Spatial filters are further classified as non-linear and linear filters.

1. Non-Linear Filters

Spatial filters utilize a low pass straining on groups of pixels with an presumption that noise occupies the higher frequency area of the band. Usually spatial filters eliminate noise to a appreciable extent but at the cost of blurring images which in turn formulates the edges in pictures undetectable.

a) Median filter

Median filter, the most significantly applied impulse noise removing filter, provides better removal of impulse noise from corrupted images by changing the individual pixels of the image as the name suggests by the median value of the gray level of the pixels from a selected neighborhood. The median of a set of values is such that half of its values in the set are lower than median value and half of them are above it and so is the most acceptable value than any other image data value for replacing the impulse corrupted pixel of a noisy image for if there is an impulse in the set selected to determine the median it will strictly lie at the ends of the set and the chance of identifying an impulse like a median to change the image pixel is very less.[2]

b) Spatial Median Filter (SMF)

The spatial median filter is also known as noise removal filter where the spatial median is calculated by calculating the spatial strength between a point and a position of point. This spatial depth is defined by In this filter after finding out the spatial strength of all points lying in the filtering mask, this information is used to decide whether the middle pixel of window is distorted or not, If middle pixel is not corrupted then it will not be changed. We then find out the spatial depth of all pixels within the mask and then sort these spatial depths in descending order .The point with largest spatial depth shows the spatial median of the set. If central pixel is corrupted with noise then it is replaced by calculated spatial median. [8]

c) Weighted Median Filter (WMF)

The centre weighted median filter is a development of the weighted median filter. The weighted median filter already designed provides more influence to various values within the window while centre weighted median filter provides more weight to the central value of a window thus simple to design and implement than other weighted median filter.[8]

2. Linear Filters

Linear filters also called an average filter are generally of two types: mean filter and wiener filter. Linear filters tries to blur sharp edges, destroy lines and other fine image information, and execute poorly in the presence of signal-dependent noise.

a) Mean Filter

Mean filter is a simple descending window spatial filter that substitutes the centre value of the window with the mean values of its all adjacent pixels values together through itself. It is implemented with the convolution mask, which offers the conclusion that is biased sum of vales of a pixel and its neighbors. It is also called linear filter. The core is square. Often 3×3 mask is used.

b) Weiner Filter

Weiner filtering process need the information on the spectra of noise and actual signal and it mechanism perform well only if the underlying signal is smooth. To control the weakness of spatial Domain filtering Donoho and Johnstone proposed wavelet based denoising schemes.

3. Non-Data Adaptive Transform

a) Spatial-Frequency Filtering

Spatial frequency domain denoising method is a type of Transform Domain, filtering where low pass filters (LPF.) is used by applying Fast Fourier Transform (FFT). Here denoising is done by designing a cut-off frequency. But these methods are time consuming and may give artificial frequencies in processed image.

b) Wavelet Domain

Wavelet Domain process is again subdivided into two different techniques i.e. linear and non-linear techniques:

(i)Linear Filters

Generally used linear filter in this classification is Wiener filter. Wiener filter yield most advantageous outcomes in the

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wavelet domain. Wiener filtering is applied where data corruption can be modeled as a Gaussian process and accuracy standard is mean square error. But wiener filtering produces filtered image which is visually more displeasing than original noisy image

(ii) Non-Linear Threshold Filtering

Non-Linear threshold filtering is the most explored domain in denoising using wavelet transform. It basically uses the characteristic of wavelet transform and the fact that wavelet transform maps noise in signal domain to that of noise in transform domain. Although signal energy becomes more concentrated into fewer coefficients in transform domain noise energy does not. The technique where small coefficients are removed leaving other coefficients untouched is known as Hard Thresholding. However this method develops spurious blips known as artifacts.

c) Data-Adaptive Transforms

Independent component analysis (ICA) transformation technique recently gain more importance include key component analysis, factor analysis, and projection detection. One advantage of using ICA is it's assumption of signal to be Non-Gaussian which helps denoising of images with Non-Gaussian and Gaussian distribution. Some applications of ICA method are machine fault recognition, seismic observing, reflection cancelling, finding concealed factors in financial data text document analysis, radio communications, audio signal dispensation, image dispensation, data mining, time series forecasting, defect detection in patterned demonstrate surfaces, bio medical signal processing. Disadvantage of ICA based methods is the computational cost because it needs a sliding window and it involves sample of at least two image frames of the same scene [8].

II. RELATED STUDY

Geoffrine Judith.M.C.et.al(2011) presented a Decision Based median filtering algorithm for the removal of impulse noise from digital images. Here, the impulse noise corrupted pixel is replaced by the median of the pixel scanned in four directions. The experimental results of this filter is applied on different type of images corrupted with almost all ratios of impulse noise support the filter in terms of objectivity and subjectivity than many of the other well-known impulse noise filters.[2]

Easwara.M.et.al(2013) used a detail-conserving filter to eliminate severe impulse noise which is based on the Cloud Model (CM). Cloud model is an uncertain conversion model, between qualitative and quantitative description that combines the concept of uncertainty and ambiguity. The normal casual number creation technique in normal cloud generator algorithm overcomes the deficiency of general method to produce random numbers. It can produce random numbers which can be knowable and repeated, and this casual numbers present to be a random sequence as a whole. The CM filter makes a great improvement in image denoising as compared to the traditional switching filters especially, at high density noise level. Thus, the cloud sculpt filter can eliminate rigorous impulse noise while preserving the image characteristics.[3]

Anamika Maurya.et.al(2014) presented a concise overview of most useful restoration model. Different types of image restoration techniques like wiener filter, inverse filter, regularized filter, Richardson –Lucy algorithm, neural network approach ,wavelet support approach, blind deconvolution are illustrated and power and weakness of each approach are recognized. The area of image reinstallation (sometimes considered as image deblurring or image deconvolution) is concerned with the reconstruction or evaluation of the uncorrupted image from a distorted and noisy image.[4]

Gabriela Ghimpeteanu.et.al(2016) considered an image decomposition model that provides a novel framework for image denoising. The model calculates the mechanism of the image to be developed in a moving frame that encodes its local geometry (directions of gradients and level lines). Then, the strategy developed is to denoise the components of the image in the moving frame in order to conserve its restricted geometry, which would have been more affected if processing the image directly. [5]

Vikas Gupta.et.al In the current era, visual information transmitted in the form of digital images is becoming a foremost scheme of communication, but through transmission the images often gets degraded with noise. The searching for efficient image denoising ways still remains a suitable challenge for researchers. Despite the complexity of the recently anticipated methods, most of the algorithms have not yet achieved a pleasing level of applicability; each algorithm has its assumptions, advantages, and restrictions. The author presented a review of some noteworthy work in the area of image denoising. Some of the popular approaches are categorized into diverse sets and an overview of different algorithms and analysis is presented here.[8]

Deepa Detani.et.al considered different types of degradations including Gaussian noise and salt-and pepper and to recover the image, hybrid filter approach has been proposed. Image degradation generally occurs due to transmission channel error, camera miss focus, atmospheric turbulence etc. Such degradations are unavoidable while a scene is captured with a camera. Salt & pepper (Impulse) noise and the additive white Gaussian noise and faintness are the types of noise that occur during broadcast and capturing. To eliminate these types of noise we have many filters like mean filter, median filter, inverse filter, wiener filter. No single filter can remove both type of noise.[9]

Filters	Author and year	Definition	Application
Median Filter	Geoffrine Judith.M.C and N.Kumarasabapathy ,2011.	This type of filter is used to remove noise from corrupted images by selecting the pixel value from neighbourhood.	Best used for eliminating salt and pepper noise and impulse noise from corrupted images by replacing the individual pixels of the image from a chosen neighborhood.
Alpha Trim	Gonzalez ,2002	Alpha-trim mean filter is	This filter is combination of

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Filter		a nonlinear digital filter, window based technique	mean and median filter. Mostly used for removing salt and pepper and Gaussian noise.
Wiener Filter	Chanchal Srivastava, Saurabh Kumar Mishra, Pallavi Asthana, G. R. Mishra, O.P. Singh,2013	Wiener filters are a class of optimum linear filters based on statistical approach.	This filter provides better results in in removing noise from photographic images. Used to minimize the mean square error among the estimated random procedure and the desired process.
Lee Filter	Shafali Gupta , Lakhwinder Kaur(2014)	Lee Filter performs noise filtering on an image using first order local statistics from the neighborhood of a specified pixel. The Lee filter converts the multiplicative model into an additive by reducing the problem of dealing with speckle noise to a known tractable case. It is non-adaptive speckle filtering. In this filter the local mean and variance of the neighborhood is evaluated. In regions with no variance, the filter simply passes the mean value of the neighborhood. In the presence of variation, the original (input) pixel value is passed unchanged.	This type of filter is used to reduce speckle noise.
Adaptive Wiener Filter	F. Jin, P. Fieguth, L. Winger an. d E. Jernigan	This filter is used to estimate the second-order statistics required by the Wiener filter. It also extends the AWA concept to the wavelet domain.	The main application of this filter is that it improves about 1dB peak-to-peak SNR (PSNR) of wiener filter.
Anisotropic Diffusion Filter	Shafali Gupta , Lakhwinder Kaur(2014)	It is a technique aiming at reducing image noise without removing significant parts of the image content, typically edges, lines that are important for	Anisotropic diffusion can be used to eradicate noise from digital images without blurring edges. Anisotropic diffusion can be used in edge detection algorithms.

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		the interpretation of the image.	
Guided Filter	Kaiming He, Jian Sun, and Xiaoou Tang	The guided filters are derived from local linear filter and uses the contents of a guide image as input image for filtering.	The guided filter is used as edge-preservin g smoothing filter like the bilateral filter but has better behaviur near the edges.
Decisio n-Base d Filter	Geoffrine Judith.M.C and N.Kumarasab apathy(2011)	In this filter only median values are used for the replacement of corrupted pixels. The corrupted and uncorrupted pixels in the image are detected by checking pixel element value against the maximum and minimum values in the window selected.	This filter overcomes the limitation of Median Filter. Enabling very good visual quality in the restored images even when the image is corrupted at very high level of salt & pepper impulse noise to the tune of 95%.

III. CONCLUSION

The major role of this paper is to draw a picture of the state of the art of the image denoising techniques. This brief study on the topic of Image Denoising attempts to illustrate the recent research work that has been done in the field. This paper compares the performance of various filters like Decision filter, Mean filter etc. for removal of different types of noises which occurred due to imperfect instruments, natural phenomenon. Median Filter is best suited for removing salt and pepper noise and impulse noise from corrupted images .Alpha Trim Filter is also used for removing Salt and Pepper noise and Gaussian noise. Weiner Filter is based on statistical approach and best suited for removing salt and pepper noise and impulse noise from corrupted images. Decision Based Filter Decision Based filter overcome the limitation of Median Filter and enables very good visual quality in the restored images even when the image is corrupted at very high level of salt & pepper impulse noise to the tune of 95%.

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