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Review of Denoising Techniques in Image Restoration

Vimal Chauhan*, Chandni Thakur**

*(M.Tech Scholar, ECE Department, Sri Sai University, Palampur
Email: vc.118560@gmail.com)

** (Assistant Professor, ECE Department, Sri Sai University, Palampur
Email: guleria_chand@yahoo.com)

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Abstract:

With the explosion in the number of digital images taken every day, the demand for more accurate and visually pleasing images is increasing. However, the images captured by modern cameras are inevitably degraded by noise, which leads to deteriorated visual image quality. Therefore, work is required to reduce noise without losing image features (edges, corners, and other sharp structures). So far, researchers have already proposed various methods for decreasing noise. This process of image restoration is crucial in many areas such as satellite imaging, astronomical image & medical imaging where degraded images need to be repaired. Each method has its own advantages and disadvantages. In this paper, we summarize some important research in the field of denoising techniques in image restoration.

Keywords — **Denoising Techniques, Image Restoration, Image Filtering.**

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I. INTRODUCTION

Images [1] can be either digital or analog. Pixel's value in digital images must be discrete where as pixel value should be continuous in Analog images. One more difference between digital and analog images is storage of pixels. It is possible to store all pixels of digital image where as not possible for analog images. In digital image processing, quality of an image is crucial to obtain high accuracy on features extraction, classification, identifying diseases etc. Noise occurs during image acquisition and transmission processes. During Transmission, images may be corrupted due to obstruction in transmission channels. Images can be classified into:

- Binary Image
- Gray Scale Image
- Color Image

Binary images [1] can be represented with only two values 0 (Black) & 1 (White). Binary image can also be classed as 1-bit image as it need only one byte for representing each pixel. These are repeatedly used where information is required only in the form of shape or general line.

Mainly there are 5 formats for storing images.

- **TIFF (Tagged Image File Format):** creates very large files and mostly used in Photoshop, Quark etc.
- **JPEG (Join Photographic Experts group):** generally used for photographs on the web. These are the images that have been compressed to store large amount of data.
- **GIF (Graphic Interchange Format):** compressed but lossless.
- **PNG (Portable Network Graphics):** extensively used for web images.
- **RAW image File:** contains data from a digital camera and also contains a huge amount of data that is uncompressed.

Today's increasingly digital world, digital images play an important role in the day today life as well as in areas of research and technology such as in

Magnetic Resonance, satellite TV including geographic information System etc. Noise is unwanted signal that interferes with the original image and degrades the visual quality of original image. The main sources of noise in digital images are imperfect instruments, problems with the data acquisition process, natural phenomena interference, transmission and compression [2]. Image noise removal is a phenomenon for removal of noise from digital image which gets affected during the acquisition or while maintaining visual quality. Thus, it is necessary to design some effective techniques for denoising of digital images. Reduce image noise is a fundamental problem in the field of image processing. This document provides several techniques for eliminating noise and also gives us knowledge about which method will provide reliable and rough estimate of the original image, given its degraded version [3].

II. VARIOUS NOISE MODELS

Noise present in the image, either additive or multiplicative form [4].

A. Additive Noise Model

Signal is additive in nature to the original signal is added to produce a noisy signal corrupted and follows the following pattern noise:

$$I(u,v) = A(u,v) + B(u,v)$$

Where,
$A(u,v)$ is the actual image and $B(u,v)$ is the noise.

B. Multiplicative Noise Model

In this model, the noise signal is multiplied to the original signal. The multiplicative noise model follows the rule:

$$I(u,v) = A(u,v) \times B(u,v)$$

Where,
The noise $B(u,v)$ is multiplied with original image $A(u,v)$ and produces corrupted image $I(u,v)$ at (u,v) pixel location.

III. TYPES OF NOISES

Image noise is the random variation of brightness or colour information in images produced by the sensor and circuitry of a scanner or digital camera. Image noise is considered as an undesirable by-product of image capture. The types of noises are as follows:-

A. Gaussian Noise (Amplifier Noise)

The standard model of gaussian noise is accessory. Gaussian noise is independent at each pixel and independent of the signal intensity.

B. Salt and Pepper Noise

An image with salt-and-pepper noise contains dark pixels at bright regions and bright pixels at dark regions [5].

C. Speckle Noise

Speckle noise is a grainy noise that intrinsic in nature. Speckle noise is a significant disturbing factor for SAR image processing.SAR is caused by unified processing of disperses signals from multiple distributed targets [1].

Fig. 1 (a) Image without noise (b) Image with noise [4].

IV. DENOISING TECHNIQUE

All accessible image restoration filters are precise somewhat by noise, which is random variety in information. Picture examination is simple undertaking after filtered. n architect working in signal handling has distinctive significance of the term channel which requires certain tasks which reveal to us the zone of enthusiasm for the picture.

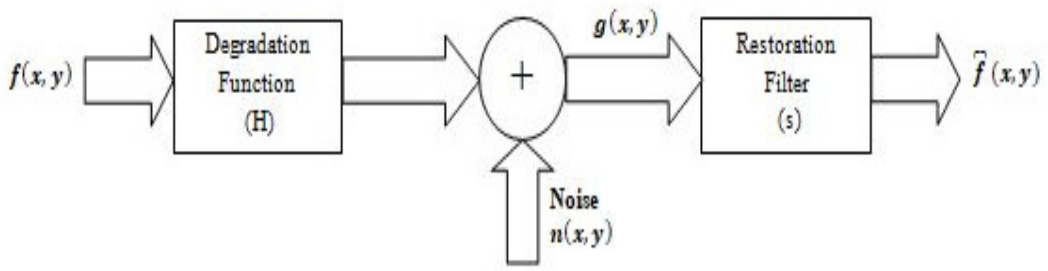

Fig. 2 Processing of Image Restoration [5].

Picture channels might be utilized to feature edges that is, portions of articles in pictures or limits between objects. Channels give better visual translation of pictures, and can likewise be utilized as an antecedent to advance computerized handling, for example, division. Picture Denoising is the way toward getting the first picture from the debased picture if estimation of the corrupting elements is known as appeared in Figure 2. It is utilized to wipe out the noise from the ruined picture while holding the edges and other significant detail without hampering the visual data of picture. In restoration process, corruption is taken to be a straight capacity given by the condition.

$$g(x,y) = h(x,y) \times f(x,y) + n(x,y)$$

Where,

$g(x,y)$ is noise free restoration can be done by using the inverse transfer function of $h(x,y)$ as the restoration filter and $n(x,y)$ is the noise.

Two types of filtering technique- linear and non-linear filtering procedures are talked about beneath:

A. Linear Filters

The approach output values are linear function of the pixels in the original image. Linear methods are easy to analyse mathematically than the nonlinear filters.

B. Non Linear Filters

These filters have accurate results because they are able to reduce noise levels without blurring the edges.

Some of the filtering techniques have been discussed below:

A. Mean Filter

Mean filter is an averaging linear filter. Here the filter figures the normal estimation of the picture with commotion in a predefined region and the middle pixel force esteem is then changed by normal estimation of pixels in the area. This cycle is rehashed for all pixel esteems in the whole picture.

Fig. 3 Mean filter used on salt and pepper noise [5].

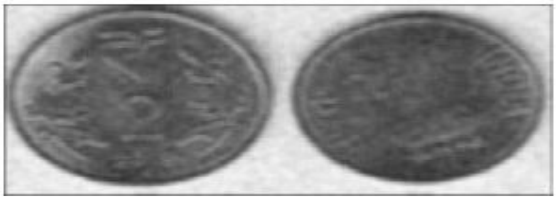

Fig. 4 Mean filter used on gaussian noise [5].

B. Median Filter

Median Filter is a best request static, non-straight channel, whose reaction depends on the situating of pixel esteems on premise of rank contained under the filter region. Median filter yield great outcome for salt and pepper commotion. These channels are essentially smoothers for picture preparing, just as

in signal handling. The advantage of the median filter over linear filters is that the median filter can eliminate the impact of information commotion esteems with enormous extents.

Fig. 5 Median filter used on gaussian noise.

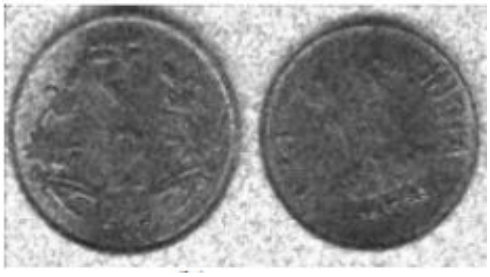

Fig. 6 Median filter used on salt and pepper noise.

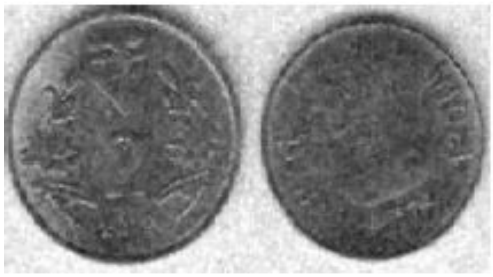

Fig. 6 Median filter used on speckle noise.

C. Adaptive Filter

These filters change the pixel based on measurable attributes of the picture locale, encased in the zone of intrigue. An adaptive filter can upgrade nature of pictures contrasted with the averaging channel. The main differ between the mean filter and the adaptive filter lies in their conduct of weight matrix differs after every emphasis in the adaptive filter, while it stays same in all the cycles in the mean filter [5]. Adaptive filters are equipped for separating non-fixed pictures, that is, pictures that have sudden changes in force. Such filters are known for their capacity in naturally following an obscure circumstance or when a sign is variable with minimal a pre known sign about the sign to be prepared. In general, an adaptive filter iteratively modifies its boundaries during examining the picture to coordinate the picture producing component.

Fig. 7 Adaptive filter used on gaussian noise.

Fig. 8 Adaptive filter used on salt and pepper noise.

Fig. 9 Adaptive filter used on speckle noise.

V. CONCLUSIONS

In this work, numerous amounts of Image Denoising Techniques are discussed. Selecting Denoising technique depends on what type of noise removal is required. It also depends on what type of information required. The purpose of this paper is to present a study of digital technology approaches to image denoising. Because images are very

important in every field so Denoising Image is an important preprocessing task before image processing as segmentation, feature extraction, etc. In the present work we discuss different noises like salt and pepper noise, Gaussian noise and speckle noise along with different denoising filters and the advantages and disadvantages of all those filters. For further extent of work, nearest local value method are considered to carry out image restoration.

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