A Comprehensive Review On Various Types of Noise in Image Processing

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Abstract - Image processing is known to be an important area to bring out the best in an image and it is useful in several areas such as remote sensing, medical field, image shaping and restoration, machine vision, pattern recognition and video processing. Noise, which is an unwanted signal or variation of brightness may destroy part of an image. Several noise removal techniques are described in this paper in other to remove noise.

Index Terms - Noise, Image processing, Salt and Pepper noise, poisson noise, speckle noise, linear filtering, median filter

1. INTRODUCTION

A digital image which is known to be the representation of a factual image as a group of numbers which can be manipulated and stirred by a computer system for the purpose of converting the entire image into numbers, the image is partitioned into tiny areas which is known as pixels (picture elements). [5][7]For each of the pixels contained in an image, the imaging device documents a group of numbers, which describe some attribute of this pixel, such as color and its brightness which is known as the light intensity while the imaging device carrying out its function, there is possibility of variation of brightness or unwanted signal which is called noise. Noise which is known to be an unwanted signal corrupts an image. Removal of noise from an image is called de-noising.[9][17]. It is also called noise reduction. The major cause of the appearance of an unwanted signal is the use of faulty equipment and most importantly natural phenomena may encroach into the image and cause degradation of the data of interest. Noise can also be present via compression and transmission errors.[11][19][24] Noise removal is one of the major steps in restoring the real quality of an image.

2. NOISE REMOVAL FROM DIGITAL IMAGE

Since it is known that noise is an unwanted signal which has great tendency to destroy the quality of an image. This unwanted signal in an image may come in form of pixels distortion, uneven lines and blurred object in an image. It can also be seen in film grain and in the shot noise of a photon detector[13],[14],[15]. The types of noise which can affect images are salt and pepper noise, Gaussian noise, poisson noise and speckle noise. Generally noise can be classified as either additive, multiplicative or impulse.[16][18] The impulse noise is a type of noise that tends to modify pixel values at random. The impulse noise is classified into static and dynamic (random) noise

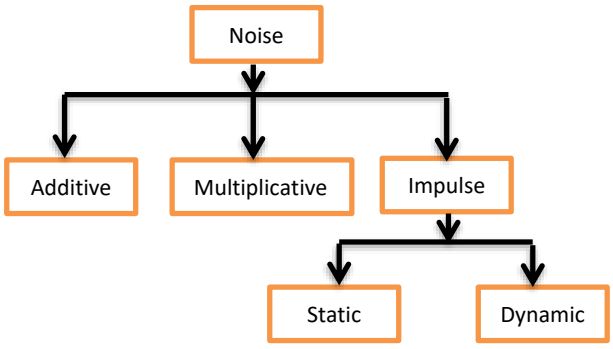

Fig. 1 – Classification of Noise

Salt and Pepper noise

This is also called impulse noise, random noise or spike noise. This type of noise is cause by sudden and sharp changes of the image signal, faulty equipment, malfunctioning of the imaging device etc. It introduces itself as casually occurring black and white pixels that is, it will have bright pixels in areas that are dark while having in bright areas, dark pixels[5][14]. Salt and Pepper noise value that is meant to be 255 for 8 –bit image is always 0. RGB images use 8 – bit intensity ranges for each color and black and white images have a single 8- bit intensity range. The image in Fig. 2a shows the original image and Fig. 2b shows the effect of salt and pepper noise on the original image.

Fig. 2a - Original image

Fig. 2b - Salt and pepper noise

(b) Gaussian noise is also called amplifier noise. It is known as a statistical noise which have Probability Density Function (PDF) which is commensurate to Gaussian distribution. It makes use of normal Gaussian distribution. It is usually either multiplicative or additive and it deals only with additive noise which is zero- mean. The principal source of Gaussian noise arises during image acquisition e.g Sensor noise introduced by poor illumination or high temperature. This noise is known as the main part of the "real noise" in an image sensor, which is known as a constant noise level in dark areas of the image[40]. The image in Fig. 3 illustrates the effect of Gaussian noise on the original image

Fig. 3 - Gaussian noise

(c) Poisson Noise is known a shot noise. It follows distribution, which is closely related to Gaussian distribution. Statistical quality of electromagnetic waves caused it to show on the image. This kind of noise shows when the number of photons present in an image that are captured with the sensors are seemingly not strong enough to pin point statistical fluctuations in a particular measurement. The Fig. 4 shows poisson noise on the original image.

Fig. 4 - Poisson noise

(d) Speckle noise: This is known as a type of granular noise which exists inherently in an image and destroys the quality of Synthetic Aperture Radar (SAR) images and active radar. It is always caused by signals from

gravity – capillary ripples, elementary scatters and present as a pedestal images which can be seen beneath the image of the sea waves. The noise in SAR is majorly more complex, because it causes difficulties for interpreting images[50]. It is depicted in Fig. 5

Fig. 5 - Speckle noise

Denoising of image of interest is the first step in image processing due to the fact that the acquired image may get corrupted in the process of capturing the image, or transmission based on noisy channel and lots more. Several denoising techniques have been in existence which are deployed in several domains. Filtering techniques are categorized as transform domain and spatial domain. For impulse type of noise, the filtering techniques are categorized as either linear filtering or non – linear filtering (Fig. 6).

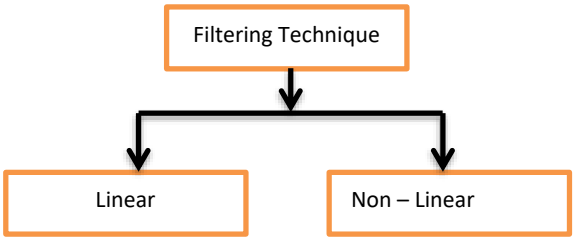

Fig 6 – Types of Filtering Technique

3. LINEAR AND NON LINEAR FILTERING TECHNIQUE

Linear Filtering[31] is known as a technique which is used to remove a particular type of noise. It is applied over all the image pixels. This type of technique is the simplest technique where the process is implemented on all the image pixels linearly without checking whether the pixel is corrupted or not unlike non linear filters. This technique is easy to implement. Example of linear filters are mean and median linear filters.

(i) Mean Filter: This is a linear filter that tends to calculate the average value of the corrupted image pixels and to reduce the noise present in an image via square window or mask (3 x 3 or 5 x 5) of grey image level. This filtering technique works by using the noisy pixel at the center of the mask or square filter, then the surrounding pixel of the center pixel will be calculated and then the center noisy pixel value will be replaced by the average value of the calculated pixels.

(ii) Median Filter: This is a type of non linear filter which works like the mean filter. The value of pixel in an image is being replaced by the median value of the surrounding pixels instead of using the mean values. This is used to reduce the degree of intensity variation between two pixels. This is the best filter due to the fact that it preserves the important details of the image.

(iii) Adoptive Median Filtering: This filter first tends to check the image for the noisy pixels, then takes the noisy pixel at the center of the 3 X 3 or 5 X 5 window, the median value is replaced. In this mechanism, the very first step checks the median value which is seen between the lowest value and the highest value in the window. The main thing this filter does in the first step is to check for residual impulse value, then if there is no impulse, it moves to the next level where it checks for the center pixel to be noisy. If the center pixel is not destroyed or corrupted, the value is left unchanged.

Table 1 show the work as researched by various authors

S/N	Author and Year	Comments
1	Hsu, Cy. et al., 2011	✓ Cellular Automata Image Denoising(CAID) toolkit was used ✓ The noisy pixels are first detected and are replaced via some predefined rules ✓ This is far better than the median filter
2	Kaisar, S. and Mahmud J. A., 2008	✓ The technique used was Tolerance Based Selective

		Arithmetic Mean Filtering Technique ✓ Tolerance wvalue was used as a threshold which was used to avoid corrupting the original image ✓ The image is less blurring
3	Chen T and Wu HR, 2011	✓ The technique used was weighted median filter ✓ It is known as a detection based mechanism
4	Ratna K., et al., 2011	✓ The technique used was Modified Median Filtering which tends to modify the corrupt pixel via a dynamic set of values ✓ It is better than median because it preserve edges
5	Ajay Kumer, B et al., 2015	✓ Digital images often have noise acquired during image acquisition, transmission and processing steps. ✓ It is very difficult to extract noise from the image without the fore knowledge of the noise model. ✓ A quantitative analysis of noise model were presented in this paper
6	Aenrex Maity and Rishev ChatterJee, 2018	✓ Noise is also known as random variation of intensity level ✓ Some extra information are added to the image pixels and turn to a noisy image. ✓ Noise is of two type: Additive noise and Multiplicative noise ✓ This paper presents the performance analysis of several filtering techniques which helps in removing noise from an image. ✓ The Performance metrics used are : MSE, SNR and PSNR etc
7	Kanika Gupta, et al, 2003	✓ The authors focused on noise removal from the original signal. ✓ This Paper reviewed various methods that were used to remove the noise
8	Rohit Verma, et al, 2013	✓ Images have been used in different fields for several purposes ✓ Noise occurs during transmission or acquisition of images ✓ Noise must first be removed before using the image ✓ Ample algorithm was used to denoise, however, it has its own advantages and disadvantages.
9	Priyanka Kanboj et al, 2013	✓ This Paper reviews the merits and demerits of various techniques e.g linear and non linear filtering techniques ✓ Noise reduction methods are employed to improve the quality of image, also to retain its originality. ✓ Noise image model in this paper, explains various types of noise that may affect image of interest
10	Rahul Sing et al, 2015	✓ This paper reviews different image denoising, methods and also explored their advantages and their disadvantages as well

		✓ Noise is introduced during image transmission and acquisition ✓ Noise always affects the quality of an image
11	Jyotsna Patil et al, 2013	✓ This paper focuses on the noise removal techniques from image. ✓ As image gotten after transmission is corrupted or partially destroyed, therefore it must be processed before using it in an application ✓ Noise model and classification of noise removal techniques were reviewed

4. CONCLUSION AND FUTURE SCOPE

In this paper, different techniques are used to remove noise from an image. Which technique will apply to which image noise depend on the behaviour and the type of noise in image. Noise model defines the type of the noises, their merits and alsodemerits. This literature concludes that there are numerous techniques for image de-noising that are applied. As there are number of image de-noising techniques used but still there is lot to happen. Further studies can be done in this field to provide more effective methodologies. Techniques that are already in use may not be able to find the optimum result thus, further studies may find the techniques that provide optimum solution to the noise.

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