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A Survey on Types of Noise Model, Noise and Denoising Technique in Digital Image Processing

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ABSTRACT: Noise is an important factor that causes significant reduction in quality, Noise appears automatically in an image during image acquisition and transmission. Identification of noise by naked eye is very difficult, so it is necessary for us to do image processing and image interpretation for satisfactory extraction of important features from the images. In the field of digital image processing it is very much essential to know the noise models, its types and its impact in an image. Denoising of the images is an unavoidable, essential pre-processing step for many image processing applications such as image compression, segmentation, identification, fusion, object recognition etc,

KEYWORDS: types of noise, digital image, features, denoising.

I. INTRODUCTION

Noise is an unwanted signal or information which destroys image quality and causes degradation in image quality [1]. A digital image is corrupted by noise during image acquisition or during image transmission. An image is affected by variety of reason such as environmental condition during image acquisition or quality of sensing element themselves.

Noise reduction is an important and basic part in image processing.

II. TYPES OF NOISE MODEL

On the basis of mathematical operations noises are classified as

1. Additive Noise

Additive noise is primarily caused by thermal noise (fundamental noise), which comes from reset noise of capacitors. Addition also finds application in image morphing.

Additive noise can be shown mathematically as:

$w(x, y) = s(x, y) + n(x, y)$

where,

$s(x, y)$ is the original signal

$n(x, y)$ is the noise which is added

$w(x, y)$ is the distorted image by noise

Examples for Additive noise

Uniform noise, Gaussian noise/Amplifier noise.

2. Multiplicative Noise

Multiplicative noise gives a magnified view of area. Thus, there is a higher random variations observed in an image. This type of noise has more intensity in brighter region than darker region. This noise is signal dependent and gives more distorted image.

Multiplicative noise can be shown mathematically as:

$w(x, y) = s(x, y) * n(x, y)$

where,

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s (x , y) is the original signal
n (x , y) is noise introduced signal
w (x , y) is corrupted signal at pixel location (x , y).
Example for Multiplicative noise
Speckle Noise.

3. Impulsive or intensity spike noise or random noise or independent noise
It is typically seen in digital images. This noise has dark pixels in bright regions and bright pixels in dark regions. It is caused by analog-to-digital converter errors, bit errors in transmission etc.
Impulsive or Intensity spike noise can be shown mathematically as:
f (i, j) = {r (i) with probability, y (j) with probability 1 – r }
where,
y (j) is gray level of a true image y at pixel location (i , j)
f (i , j) is gray level of the noisy image f at pixel (i , j)
r (i) is random number
r is noise ratio
Example for Impulsive or Intensity spike noise
salt and pepper noise.

III.TYPES OF NOISE

There are different types of noise in image which can reduce image quality.
1. Uniform noise
When the grey level value of the noise is distributed uniformly in an image in a specific range then this type of noise is called a uniform noise [2].
The probability distribution of uniform noise is

$$Pu(z) = \begin{cases} 1/(b-a) & if\ 0 \leq z \leq b \\ 0 & otherwise \end{cases}$$

Mean= (a + b) / 2
Variance= $(b – a)^2 / 12$

2. Gaussian noise/amplifier noise/electronic noise:
Gaussian noise is also known as amplifier noise or electronic noise, because it is produced by amplifier or detector. It uses Gaussian distribution i.e. normal distribution. Gaussian noise is a statistical noise having Probability Density Function (PDF) which is equal to Gaussian distribution. It is additive in nature, each pixel is independent and signal intensity of each pixel is also independent. Thus, each and every pixel of the image affected. The mean of each pixel of an image i.e. affected by Gaussian noise is zero [3, 13].
The PDF of Gaussian random variable is given by

$$F(g) = 1 \quad \frac{e^{-(g-m)2/2\sigma 2}}{\sqrt{2\pi\sigma}}$$

F (g) = Gaussian distribution noise in image
σ = Standard deviation
m = mean value
variance => $m^2 = \sigma^2$

3. Speckle Noise
Speckle noise originates in the image because of coherent processing of back scattered signals from multiple distributed points. The quality of images gets deteriorated.
This noise [4] can be modelled by random value multiplications with pixel values of the image and can be expressed as
$J = I + n * I$
Where, J is the speckle noise distribution image,
I is the input image
n is the uniform noise image by mean *o* and variance *v*.

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4. Salt and pepper noise/Impulse noise/spike noise/random noise/independent noise
The Impulse noise is also called salt and pepper noise [5]. Black and White dotes appears in the image .As a result it is called as salt-and-pepper noise. Image having salt and pepper noise will have dark pixel in bright area that contain the extremely low value 0 and bright pixel in dark areas that contain the extremely high value 1. The noise originates in the image because of sharp and sudden change in image signal.
For 8 bit image, the typical value for pepper noise is 0 and 255 for salt noise.
The PDF of impulse noise is given by

$$P(z) = \begin{cases} p_a & for\ z=a \\ p_b & for\ z=b \\ 1 - (p_a + p_b) & for\ z=k\ (0 < k < 2^n - 1) \end{cases}$$

If b>a, intensity 'b' will appear as light dot in the image. Otherwise intensity 'a' appears like a dark dot.

$$\text{mean} = (0) + p_a + k(1 - p_a + p_b) + 2^n - 1)\, p_b$$
$$\text{variance}^2 = (0\text{-m})^2\, p_a + (k\text{-m})^2 (1 - p_a + p_b) + (2^n\text{-}1\text{-m})^2\, p_b$$

5.Poission Noise/photon noise/shot noise
Poisson noise [6] is appears when the number of photon sensed by the sensor is not sufficient to provide detectable statistical information [1]. This type of noise is formed due to the electromagnetic wave such as x-ray, visible light and gamma ray.
The probability density function of photon noise is
$P(P/\rho, T) = (\rho T)^P e^{-\rho T} / P!$
Where ρ is the rate of intensity parameter measured in photon per T second

6.Rayleigh noise:
Radar range and velocity images typically contain noise that can be modelled by the Rayleigh distribution [7].
The probability density function of Rayleigh noise is

$$P(z) = \begin{cases} 2/b\,(z-a)e^{-\frac{(z-a)^2}{b}} & for\ z >= a \\ 0 & for\ z < a \end{cases}$$

Mean $=a+\sqrt{\pi b/4}$
Variance σ^2=b $(4-\pi)/4$

7. Gamma noise:
Gamma noise is generally seen in the laser based image. It obeys the Gamma distribution [7, 8].
The probability distribution function of Gamma noise is

$$(g) = \begin{cases} a^b g^{b-1} e^{-ag} / (b-1)!, & for\ g \geq 0 \\ 0, & for\ g < 0 \end{cases}$$

Where the parameter a > 0, b is a positive integer and "! " indicate the factorial.
Mean $\bar{z} = b/a$
Variance $\sigma^2 = b/a^2$

8. Periodic noise
This noise is generated from electronics interference, especially in power signal during image acquisition. In a video stream the periodic noise is typically caused by the presence of electrical or electromechanical interference during video acquisition or transmission. This type of noise is most efficiently reduced with frequency domain filtering, which isolates the frequency occupied by the noise and suppress them using band-reject filter.

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9. Structural noise
Structural noise may be periodic, stationary or nonstationary, aperiodic, detector striping and detector banding in nature. The periodic Structural noise commonly causes due to interface between electronic components. The structural noise having periodic, nonstationary in nature has vary in amplitude, frequency and phase [9].
Structural aperodic noise generally created in JPEG noise.

10. White noise
In signal processing, white noise is a random signal with a constant power spectral density. The white noise is so named because it's analogous to white light. In particular each sample has a normal distribution with zero mean, then the signal is said to be Gaussian white noise. In a sample a white noise signal may be sequential in time. In digital image processing, the pixels of a white image are typically arranged in a rectangle grid [10].

11. Brownian noise
Brownian noise is given after the name of botanist Robert Brown who discovered Brownian motion in the 1800s. Brown noise has a spectral density that is inversely proportional to its square of frequency [11]. In the other words its power significantly decreases as its frequency increases. As a result brown noise has a lot more energy at low frequency as compare to its higher frequency. Brownian motion is causes due to the random movement of suspended Particles in fluid [12].

IV. IMAGE FILTERING

Image denoising is the unavoidable, essential pre-processing first step in many image processing applications. Filters are used best for removing noise from the images. To detect and then filter the image so that data can be analyzed for further process. Image denoising helps in noise reduction, interpolation and re-sampling. Image is filtered through various techniques that depend on the behaviour and the type of the image, it is the big challenge for the researchers to remove the noise from the image while keeping the details/information of the image preserved. Basically two methods are used to remove noise named as linear and non-linear methods [14]. Linear methods are fast as compared to non-linear methods but linear methods are not able to preserve the details/information of the image in comparison to non-linear methods. Further these methods are described as below:-
g (x,y) - > filter - > f (x,y)
where,
g (x,y) is corrupted image
f (x,y) is filtered image

LINEAR FILTERS:-Linear filters are used to remove certain type of noise. Gaussian or Averaging filters are suitable for this purpose. These filters also tend to blur the sharp edges, destroy the lines and other fine details of image, and perform badly in the presence of signal dependent noise [14].

NON-LINEAR FILTERS:-In recent years, a variety of non-linear median type filters such as rank conditioned, weighted median, relaxed median, rank selection have been developed to overcome the shortcoming of linear filter [14].

1. Adaptive Filtering
Adaptive Median [15] is a "decision-based" or "switching" filter with the purpose of first identifies possible noisy pixels and then replaces them using the median filter or its variants, though leaving all other pixels unaffected. This filter is good at detecting noise even at a far above the ground noise level. The adaptive structure of this filter ensures with the intention of most of the impulse noises are detected even at a far above the ground noise level provided with the purpose of the window size is large enough. The performance of AMF is good at subordinate noise density levels, due to the fact that here are only fewer corrupted pixels that are replaced through the median values. At higher noise densities, the number of replacements of dishonored pixel increases significantly; increasing window size will provide better noise removal performance; however, the dishonored pixel values and replaced median pixel values are less connected. The adaptive median filter (AMF) adopts adaptive window size and performs well at low noise density, but the filter window size has to be expanded when the noise density increases which may lead to blurring the image.

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2. Median Filtering
In signal processing, it is often desirable to be able to perform some kind of noise reduction on an image or signal. The median filter is a nonlinear digital filtering technique, often used to remove noise. Such noise reduction is a typical preprocessing step to improve the results of later processing (for example, edge on an image). Median filtering is very widely used in digital image processing because, under certain conditions, it preserves edges of the images while removing noise. Median is a non-linear local filter whose output value is the middle element of a sorted array of pixel values from the filter window. Since median value is robust to outliers, the filter is used for reducing the impulse noise. Now we will describe median filtering with the help of example in which we will placed some values for pixels. Example To demonstrate, using a window size of three with one entry immediately preceding and following each entry, a median filter will be applied to the following simple 1D signal:
x = [2 80 6 3] So, the median filtered output signal y will be:
y[1] = Median[2 2 80] = 2
y[2] = Median[2 80 6] = Median[2 6 80] = 6
y[3] = Median[80 6 3] = Median[3 6 80] = 6
y[4] = Median[6 3 3] = Median[3 3 6] = 3
i.e. y = [2 6 6 3].

3. Vector median filters
Vector median filters [16] are primarily designed for noise reduction in color images. There are various vector median filtering techniques, within which the one called hybrid vector filtering, which utilizes a number of sub-filters of different types and defines the output as a linear or nonlinear combination of the input vectors. For example, the extended vector median filter combines the VMF with linear filtering. Near edges, this filter behaves like the VMF; while in smooth areas it behaves like the arithmetic mean filter (AMF). The main disadvantage of the hybrid filters is that the output is often the artifact. Although there are various sub-filters in a hybrid filter, only one sub-filter is chosen for a certain image part (e.g., in EVMF, the VMF for the edge areas while the AMF for the smooth areas). Consequently, this kind of the filters is termed as "hybrid" not "ensemble".

4. Unsymmetric Trimmed Median Filter
Alpha Trimmed Mean Filtering (ATMF) is a symmetrical filter [17] where the trimming is symmetric at also end. In this procedure, still the uncorrupted pixels are also trimmed. This leads to loss of image details and blurring of the image. In order to overcome this disadvantage, an Unsymmetric Trimmed Median Filter (UTMF) is proposed. In this UTMF, the selected 3x 3 window elements are arranged in either increasing or decreasing order. Then the pixel values 0’s and 255’s in the image (i.e., the pixel values responsible for the salt and pepper noise) are removed from the image. Subsequently the median value of the remaining pixels is taken. This median value is used to replace the noisy pixel. This filter is called trimmed median filter because the pixel values 0’s and 255’s are removed from the selected window. This procedure removes noise in better way than the ATMF.

5. Hybrid Filtering
Noise is the most annoying problem [18] in image processing. One way to get rid of this problem is the development of such a robust algorithm that can perform the processing tasks in presence of noise. The other way is to design a filtration process to eliminate the noise from images while preserving its features, edges and details. Noise introduces random variations into image that fluctuate the original values to some different values. Causes which may introduce noise to images include flaws in data transmission, imperfect optics, sensor malfunctioning, processing techniques and electronic interference. Mathematical morphology is a methodology specifically designed for the analysis of geometrical structures in an image by interested it through small patterns called structuring elements. The resultant image operators are nonlinear and found functional for many applications like edge detection object segmentation, noise suppression and exploring geometrical structures of images.

6. Iterative guided filtering
Recently, several techniques to enhance the quality of flash/no-flash image [19] pairs have been projected. At the same time as the flash image is better exposed, the lighting is not soft, and generally results in specularities and unnatural appearance. In the meantime, the no-flash image tends to have a relatively low signal-to-noise ratio (SNR) at the same time as containing the natural ambient lighting of the scene. The key idea of flash/no-flash photography is to create a

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original image that is closest to the look of the real scene by having details of the flash image at the same time as maintaining the ambient clarification of the no-flash image. Eisemann and Durand used bilateral filtering to give the flash image the ambient tones from the no-flash image removed flash artifacts, but did not test their method on top of no-flash images containing severe noise. As different to a visible flash used by recently Krishnan and Fergus used both near-infrared and near-ultraviolet illumination for low light image improvement. Their so-called “dark flash” provides high-frequency detail in a less disturbing way than a visible flash does even though it results in incomplete color information.

7. Bilateral filtering
Bilateral filtering is another non-linear filtering method [20] which can be regarded as an extended version of the low pass Gaussian filtering. In essence, it is a simple arrangement of a domain filter, similar to the Gaussian filter, and a range filter which is a Gaussian function of local intensity difference. The main idea is that only perceptually analogous colors are averaged mutually to keep away from unpredicted colour combination in images. Barash unified anisotropic diffusion and non-linear bilateral filtering as an additional effective edge preserving filtering technique. However, one of the main limitations of bilateral filtering so as to the range filter coefficients rely heavily on actual pixel intensity values, as it does not take into explanation any regional characteristics, which may in turn have been partial by noise therefore potentially resulting in smoothed textured regions.

8. Trilateral filter
In order to overcome the limitations of bilateral filtering, Garnett proposed [20] a trilateral filter employing a local image statistic for identifying the noisy pixels. The trilateral filter proposed in was mainly aimed at denoising images corrupted with impulse noise, although it was shown to be efficient for removing Gaussian and mixed noise too. The weighting function used by Garnett trilateral filter contains spatial, radio-metric, and impulsive components. A third weighting function, the impulsive component based on a rank-order statistic of unconditional differences (ROAD), removes high frequency impulse noise. The resulting trilateral filter performs fine in removing assorted noise as well as in removing impulse noise. Another trilateral filter was presented for high contrast images and meshes.

V. CONCLUSION AND FUTURE WORK

This paper provides survey on different types of noise models, noise and its impact in the digital image during image acquisition and transmission, and also many image filtering algorithm/approach which are used for removing noise from the images. Which filtering algorithm/method will apply to which image noise depend on the behaviour and the type of noise or noise image. This survey concludes that there is numerous algorithm/method for image de-noising that are applied. As there are number of image de-noising algorithm/method 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 using may not be able to find the optimum result thus further studies may find the best algorithm/method that provides optimum solution to the noise.

REFERENCES

[1] ”Digital Image Processing” S Jayaraman, S EsaKkirajan, T VeeraKumar, Tata McGraw Hill,2009
[2] P. Kamboj, “A brief study of various noise models and filtering technique”, Journal of Global Research in Computer Science ,Volume 4, No. 4, April 2013
[3] Kalpana, and Harjinder Singh, “ Review Paper:to study the image denoising techniques”, Vol. 02, pp.127-129, Nov-2015.
[4] Dainty, J.C. 1971. Detection of images immersed in speckle noise. Optica Acta, Vol. 18, No. 5, pp.327-339.
[5] R. H. Chan, Chung-Wa Ho, M. Nikolova, “Salt and Pepper Noise Removal by Median Type Noise Detectors and Detail –Preserving Regularization,” IEEE Transactions on Image Processing, Vol. 14, No.10, pp. 1479-1485, October 2005.
[6] Alessandro Foi, Mejdi Trimeche, Vladimir Katkovnik, and Karen Egiazarian. Practical Poissonian-Gaussian noise modeling and fitting for singleimage raw-data. IEEE Transactions on Image Processing, 17(10):1737–1754, 2008.
[7] Kamboj P. & Rani V., (2013) “A Brief study of various noise models and filtering techniques,”Journal of Global Research in Computer Science, Vol. 4, No. 4.
[8] T. Chhabra, G. Dua and T. Malhotra (2013) “Comparative Analysis of Denoising Methods in CT Images” International Journal of Emerging Trends in Electrical and Electronics, Vol. 3, Issue 2.
[9] Behrens R. T. (1990) “Subspace signal processing in structured noise,” Thesis, Faculty of the Graduate School of the University of Colorado, the degree of Doctor of Philosophy, Department of Electrical and Computer Engineering.
[10] Dougherty G. (2010) “Digital Image Processing for Medical Applications,” second ed., Cambridge university press.

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[11] Bhattacharya J. K., Chakraborty D., & Samanta H. S., (2005) "Brownian Motion - Past and Present," Cornall university library. arXiv:cond-mat/0511389
[12] Radenovic A., "Brownian motion and single particle tracking," Advanced Bioengineering methods laboratory, Ecole polyteachenique federal de Lausanne.
[13] Priyanka Kamboj et al.," Brief study of various noise model and filtering techniques", vol.4, No.4, pp.166-171, April 2013.
[14] Rohit Verma, and Dr. Jahid Ali," A Comparative study of various types of image noise and efficient noise removal techniques", vol.3, issue 10, pp. 617-622, October 2013.
[15] K.Aiswarya,V.Jayaraj,D.Ebenezer "A New Switching-Based Median Filtering Scheme and Algorithm for Removal of High Density Salt and Pepper Noise in Images" 2010 Second International Conference on Computer Modeling and Simulation pp;409-413
[16] Ling Zhong, Yun Zhang "An Ensemble Vector Median Filter For Color Image Denoising" 2010 11th Int. Conf. Control, Automation, Robotics and Vision Singapore, 7-10th December 2010 pp;2485-2490..
[17] S. Esakkirajan, T. Veerakumar "Removal of High Density Salt and Pepper Noise Through Modified Decision Based Unsymmetric Trimmed Median Filter" IEEE SIGNAL PROCESSING LETTERS, VOL. 18, NO. 5, MAY 2011 pp;287-290.
[18] Isma Irum" A Nonlinear Hybrid Filter for Salt & Pepper Noise Removal from Color Images" Comsats Institute of Information Technology Vol.13,February 2015 pp;79-86.
[19] Hae-Jong Seo and Milanfar, "Robust flash denoising/deblurring by iterative guided filtering" EURASIP Journal on Advances in Signal Processing 2012 pp;1-19.
[20] Nasir Rajpoot "A multiresolution framework for local similarity based image denoising" Sciverse Science Direct (2012) pp;2938–2951.