EXCELLENT PUBLISHERS

International Journal of Current Research and Academic Review

ISSN: 2347-3215 Volume 2 Number 3 (2014) pp. 83-89

www.ijcrar.com

A Review of Denoising Filters in Image Restoration

Medhavi Aggarwal*, Ranjit Kaur and Beant Kaur

Department of ECE, University College of Engineering , Punjabi University, Patiala, India

***Corresponding author**

KEYWORDS

Digital images;
Image restoration;
Denoising techniques.

A B S T R A C T

The massive production of digital images in the communication world has led to the need for efficient image restoration methods. Image restoration is the process of obtaining a noise free original image from a corrupted/noisy image. It forms an important process in image processing. The restoration of degraded images can be applied in many application areas that are needed to repair images. The aim of this paper is to analyze various image restoration or denoising techniques. These techniques help us to recover the original image from the degraded image while maintaining the originality of the image as much as possible.

Introduction

In modern age, visual information is often transmitted in the form of digital images, but the images so obtained after transmission are often corrupted with noise which is the undesirable and unwanted element which is intruded in the image at the time of acquisition or transmission (Xiaoliang Qian et al., 2010) from sender to receiver, thereby diminishing the quality of image. Therefore, processing is required for the received image before it can be used in applications. To produce a visually high quality image, image restoration or denoising is required which involves the manipulation of the image data resulting into a noise free image. An image can be degraded or corrupted due to various reasons like - improper opening of the shutter, atmospheric disturbances, misfocussing, motion between camera and object etc.

In this paper role of different filters such as mean filter, median filter and adaptive filter is studied restoring images corrupted with noise.

Different types of noises in digital images

Image noise is the random variation of brightness or color 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 :-

(i) Gaussian noise (Amplifier noise) - The standard model of amplifier noise is additive. Gaussian noise is independent at each pixel and independent of the signal intensity (Laxmi Laxman et al., 2013).

(ii) Salt-and-pepper noise - An image containing salt-and-pepper noise will have dark pixels in bright regions and bright pixels in dark regions (Laxmi Laxman et al., 2013).

(iii) Speckle noise - Speckle noise is a granular noise that inherently exists in and degrades the quality of the active radar and synthetic aperture radar (SAR) images. SAR is caused by unified processing of backscattered signals from multiple distributed targets (Laxmi Laxman et al., 2013).

These are only a few types of noises amongst a large world of undesirable and unwanted disturbances in an image. Further exposition of aforesaid undesirable elements is as below:

Gaussian Noise

Gaussian noise is one type of noise which is evenly distributed over the signal. This means that each pixel in the noisy image is the sum of the true pixel value and a random Gaussian distributed noise value Asoke Nath, 2013). As the name indicates, this type of noise has a Gaussian distribution, which has a bell shaped probability distribution function.

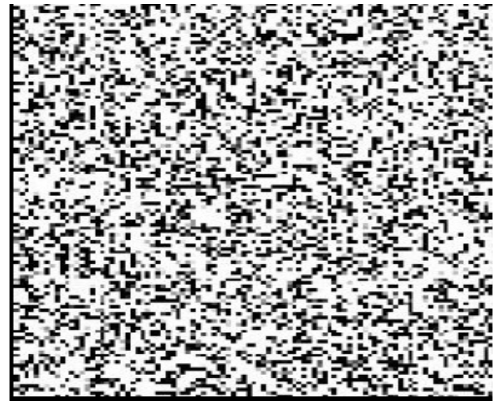

Figure 1 : Gaussian Noise (Asoke Nath, 2013)

This noise can be depicted with the help of Figure 1.

Salt and Pepper

Salt and Pepper noise is yet another type of noise. It is an impulse noise which is actually the intensity spikes. This type of noise comes due to errors in data transmission. The salt and pepper noise is generally caused by malfunctioning of pixel elements in the camera sensors, faulty memory locations, or timing errors in the digitization process. Salt and pepper noise is shown as below.

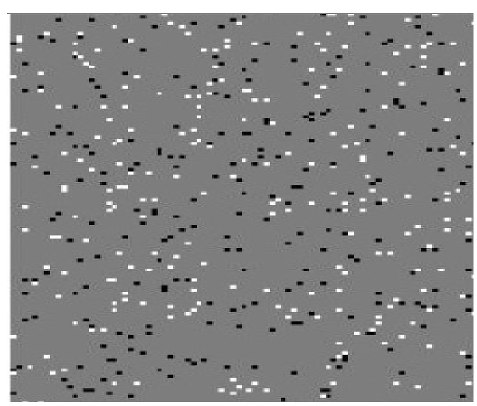

Figure 2 : Salt and Pepper Noise (Asoke Nath, 2013)

Speckle Noise

The third type of noise is Speckle noise. It is multiplicative noise unlike the Gaussian or Salt and Pepper type noise. Speckle noise occurs in all coherent imaging systems such as laser, Synthetic Aperture Radar (SAR) or in acoustics (Muthukumar et al., 2010). Speckle noise follows a gamma distribution function. The figure below shows speckle noise.

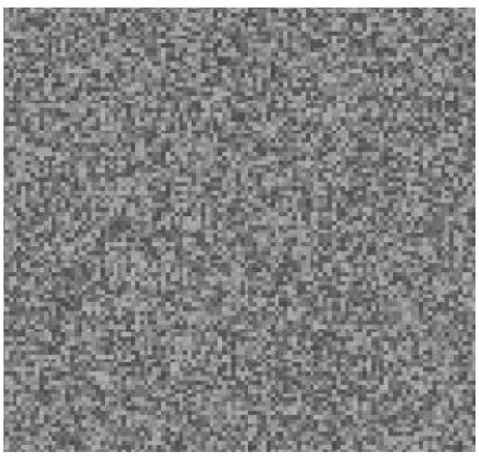

Figure.3 Speckle Noise (Asoke Nath, 2013)

Brownian Noise

Brownian noise comes under the category of fractal or 1/f noises mathematical model of which is called fractal Brownian motion. Fractal Brownian motion is a non-stationary stochastic process that follows a normal distribution. Brownian noise is a special case of 1/f noise. It can be obtained by integrating white noise. Brownian noise looks like follows.

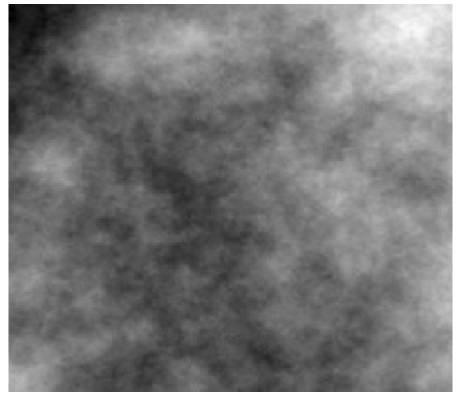

Figure.4 Brownian Noise (Asoke Nath, 2013)

Various image restoration filters

Most images are affected to some extent by noise, which is unexplained variation in data. Image analysis is often simplified if this noise can be filtered out. Just as filters are used in chemistry to free liquids from suspended impurities by passing them through a layer of sand or charcoal; engineers working in signal processing have extended the meaning of the term filter to include operations which accentuate features of interest in data. Employing this broader definition, image filters may be used to emphasize edges that is, boundaries between objects or parts of objects in images. Filters provide an aid to visual interpretation of images, and can also be used as a precursor to further digital processing, such as segmentation.

Image Restoration or Denoising is the process of obtaining the original image from the degraded image given the knowledge of the degrading factors as shown in Figure 5. It is used to remove the noise from the corrupted image while retaining the edges and other details as much as possible.

In restoration process, degradation is taken to be a linear spatially invariant operator given by the equation (1).

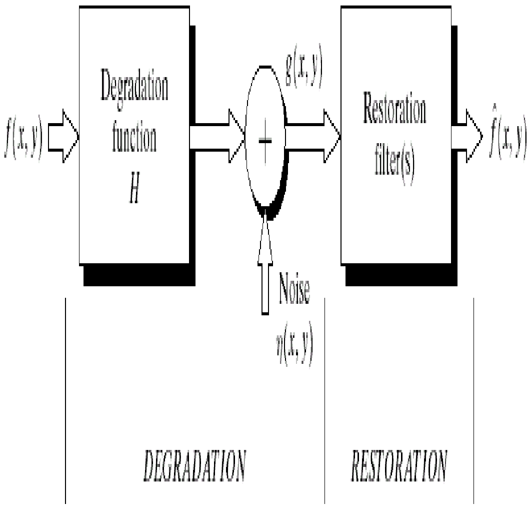

Figure.5 Processing of Image Restoration [7]

$$g(x, y)= h(x, y) * f(x, y) + \eta(x, y)\text{........} (1)$$

where, if g(x, y) is noise free, restoration can be done by using the inverse transfer function of h(u, v) as the restoration filter and η(x, y) is the noise.(Al-Nauimy, 2012)

There are two types of noise filtering approaches - linear and non-linear filtering approaches. In linear approach output values are linear combinations of the pixels in the original image. Linear methods are far more amenable to mathematical analysis than the nonlinear ones, and are consequently far better understood. On the other hand nonlinear filters are more diverse and difficult to categorize, and are still an active area of research. They are potentially more powerful than linear filters because they are able to reduce noise levels without simultaneously blurring edges. However, their theoretical foundations are far less secure and they can produce features which are entirely spurious. Therefore care must be taken in using them. Some of the denoising or filtering techniques have been discussed below:

Mean filter

Mean filter is an averaging linear filter (Asoke Nath, 2013). Here the filter computes the average value of the corrupted image in a pre-decided area and the center pixel intensity value is then replaced by that average value. This process is repeated for all pixel values in the image.

Figure.6 Mean filter used on Salt and pepper noise (Rohit Verma, and Jahid Ali, 2013)

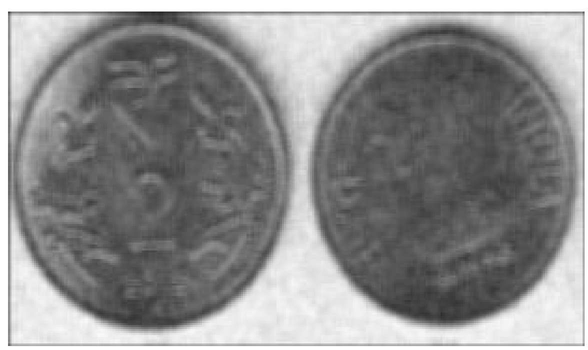

Figure.7 Mean filter used on Gaussian noise (Rohit Verma, and Jahid Ali, 2013)

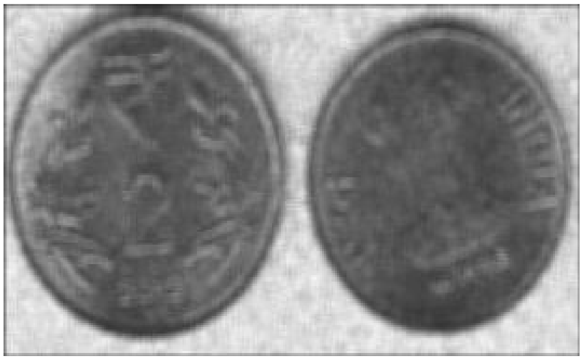

Figure.8 Mean filter used for Speckle noise (Rohit Verma, and Jahid Ali, 2013)

The above Figure 6-Figure 8 shows the effect of using mean filter of size 5X5 on different types of noise (Rohit Verma, and Jahid Ali, 2013)

Median Filter

Median filter is a best order static, non-linear filter, whose response is based on the ranking of pixel values contained in the filter region. Here the center value of the pixel is replaced by the median of the pixel values under the filter region (Al-Nauimy, 2012; Rohit Verma, and Jahid Ali, 2013). Median filter is good for salt and pepper noise. These filters are widely used as smoothers for image processing, as well as in signal processing. A major advantage of the median filter over linear filters is that the median filter can eliminate the effect of input noise values with extremely large magnitudes.

Figure.9 Median filter used for Salt & pepper noise

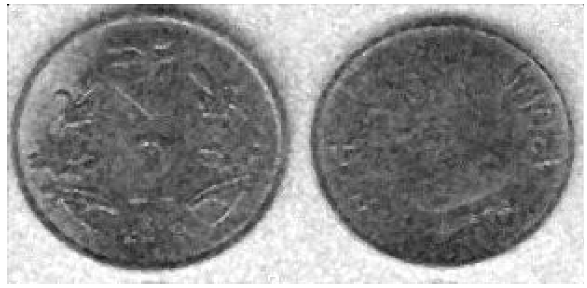

Figure.10: Median filter used for Gaussian noise (Rohit Verma, and Jahid Ali, 2013)

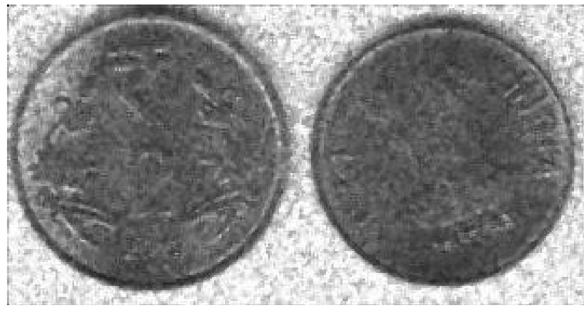

Figure.11: Median filter used for Speckle noise (Rohit Verma, and Jahid Ali, 2013)

Median filter is well known for maintaining the sharpness of the image while removing the noise out of it (Shabnam Sultana et al., 2013) Figure 9-Figure 11 (Rohit Verma, and Jahid Ali, 2013) shows the effect of median filter on different types of noise.

Adaptive Filter

These filters change their behavior on the basis of statistical characteristics of the image region, encompassed by the filter region.

An adaptive filter does a better job of denoising images compared to the averaging filter. The fundamental difference between the mean filter and the adaptive filter lies in the fact that the weight matrix varies after each iteration in the adaptive filter, while it remains constant throughout the iterations in the mean filter. Adaptive filters are capable of denoising non-stationary images, that is, images that have abrupt changes in intensity. Such filters are known for their ability in automatically tracking an unknown circumstance or when a signal is variable with little a priori knowledge about the signal to be processed. In general, an adaptive filter iteratively adjusts its parameters during scanning the image to match the image generating mechanism. This mechanism is more significant in practical images, which tend to be non-stationary (Asoke Nath, 2012). Figure 12-Figure 14 shows the effect of adaptive filter on different types of noise.

Figure.12 Adaptive filter used for Salt & pepper noise (Rohit Verma, and Jahid Ali, 2013)

Figure.13 Adaptive filter used for Gaussian noise (Rohit Verma, and Jahid Ali, 2013)

Figure.14 Adaptive filter used for Speckle noise (Rohit Verma, and Jahid Ali, 2013)

Conclusions

In the present work different image denoising filters and the merits and demerits of all those filters is discussed along with different noise models such as Gaussian noise, salt and pepper noise, speckle noise and Brownian noise. Depending on the noise present in an image a particular algorithm is to be selected.

To summarize, it is concluded that filters are an important engineering technique which help to produce a good quality image by removing noises from an image which are bound to creep into an image because of various reasons which may be controllable or sometimes uncontrollable. The filtering approach to be adopted for a better result depends upon the kind of noise which exists in an image. For salt and pepper noise, the median filter is optimal compared to mean filter and adaptive filter. The adaptive filter proves to be better than the mean filter but has more time complexity. The median filter has no noise present in it and is close to the high quality.

References

Al-Nauimy,W "Comparative Study between Different Denoising Filters for Speckle Noise Reduction in Ultrasonic BMode Images", IEEE, July, 2012.

Asoke Nath, "Image Denoising Algorithms: A Comparative study of Different Filtration approaches used in image restoration", IEEE, International Conference on Communication Systems and Network Technologies, 2013.

Charu Khare, Kapil Kumar Nagwanshi , " Image Restoration Technique with Non Linear Filter", International Journal of Advanced Science and Technology Vol. 39, February, 2012 .

Jianjun Zhang, "An efficient median filter based method for removing random-valued impulse noise", Science Direct, Digital Signal Processing 20 (2010).

Laxmi Laxman, V Kamalaveni, K A Narayanankutty, "Comparative Study On Image Restoration Techniques Using The Partial Differential Equation And Filters", International Journal of Engineering Research & Technology (IJERT),Vol. 2 Issue 7, July – 2013, pp: 55-59.

Muthukumar,S P.Pasupathi, S.Deepa, Dr. N Krishnan, "An efficient Color Image Denoising method for Gaussian and Impulsive Noises with blur removal", IEEE,2010.

Rohit Verma, Dr. Jahid Ali, "A Comparative Study of Various Types of Image Noise and Efficient Noise Removal Techniques", International Journal of Advanced Research in Computer Science and Software Engineering, Volume 3, Issue 10, October 2013, pp: 617-622.

Shabnam Sultana, M.Varun Kumar, N.Asha, "Comparison of Image Restoration and Denoising Techniques", International Journal of Advanced Research in Computer Science and Software Engineering, Volume 3, Issue 11, November 2013, pp: 337-341.

Xiaoliang Qian, Lei Guo, Bo Yu, "An Adaptive Image Filter Based on Decimal Object Scale For Noise Reduction and Edge Detection", International Conference on Intelligent Computation Technology and Automation, IEEE, 2010