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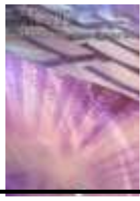

Image De-noising Techniques: A Comparative Study

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Abstract Image processing techniques can be used to distinguish images or enhance its quality. The occurrence of noises is common during electronic transmissions between devices, and the restoration of the images damaged during these transmissions is a challenging endeavor. This paper detail noises that are present in corrupt images and noise reduction techniques that can be used to minimize or eliminate noises from the images. Additionally a comprehensive survey is provided and summarises the recent implemented noise reduction techniques for noise removal from images and based of quality preservation purposes. This visualization will assist the development process of new techniques.

Keywords: **Gaussian, noise, Poisson noise, Salt and Pepper noise, Speckle noise, Linear Technique, Nonlinear Technique.**

1. Introduction

Image processing involves the modification of digital images. Digital images are often degraded by noises during its acquisition/transmission via electronic communication devices by blurring and artifacts. De-noising applications can be applied to the original images before its transmission to prevent this from happening. An image is a finite set of digital values called picture elements, where each element has a particular location or can be defined as the representation of a 2-D functions $f(x, y)$, and x, y are the spatial coordinates. The amplitude of f at any pair of the coordinates is called the intensity or gray level of the image at that point. A 1-bit dimensional is an array of numbers between 0 - 255(Nawafil, 2019). Each pixel in an image dictates the color and brightness.

Researchers are working on developing image restoration algorithms for noise removal (in images). When a degraded image is processed, a balanced approach that removes noises while also preserving image details should be used (Ali & Al Shaikhli, 2017; Nawafil, et al. 2018).

This paper is organized in the following manner. Section two defines the different types of noises, while section three describes the de-noising techniques and their respective types. Section four outlines the literature about the developed algorithms, which are then discussed in Section five. Section six concludes this paper.

2. Image Noise

A random dissimilarity in image intensity is defined as noise. It is always present in an image via acquisition, transmission, or coding when processed by electronic devices. The processing leads to unwanted artifacts such as unrealistic edges, artifacts, blurred objects, disturbing background scenes, and unseen lines corners. Noise can also be defined as pixels with different intensities within the same picture (Nisha et al.2015).

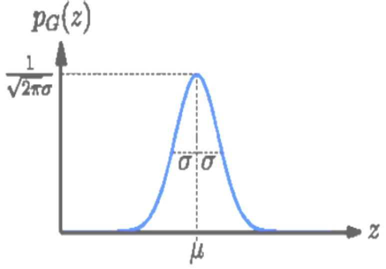
a) Gaussian Noise

Gaussian noise is produced by natural sources, such as the thermal vibration of atoms, and disconnection radiation generated by warm objects. Gaussian noise is also called an electronic noise as it appears in amplifiers and detectors. It randomly disturbs the gray values in digital images, which is why the Gaussian noise model normalizes its histogram in terms of its gray value, or possess characteristics that can be elucidated in a probability density function (PDF). Typically, the noise can be characterized as an additive white random noise for it to fit into the Gaussian noise model. An adaptive filter can be used to remove this type of noise due to its similarity with electronic error (Abubakar, 2013; Gao, 2018).

A probability density function (PDF) is present as a Gaussian, and identified z, as per the following equation:

$$p(z) = \frac{1}{\sqrt{2\pi}\sigma} e^{-(z-\mu)^2/2\sigma^2} \tag{1}$$

Where z is the gray level, μ is the present mean value, and σ is the standard deviation.



(1)

Figure 1: Gaussian Noise

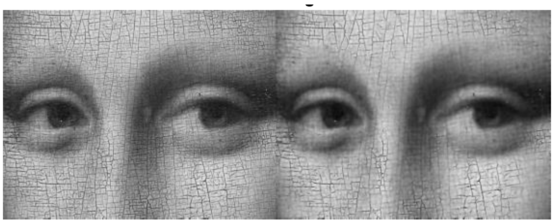


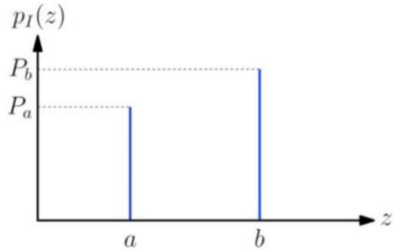
Figure 2: (a) Original Image (b) Gaussian Noise

b) Salt and Pepper Noise

Salt and pepper noise is defined as the impulse/random noise. This model deal with pixels that have different colors to its neighboring pixels in an image. Typically, random noises, which degrades grayscale pixel values, works by substituting minimum pixels values with maximum values. These types of random noises represent positive /negative impulses. The white spots (salt) represent the positive impulses, while the black spots (pepper) represent the negative impulses in the image (Abubakar, 2013; Li et al.2014).

$$p(z)=\begin{cases} p_a & for \quad z=a \\ p_b & for \quad z=b \\ 0 & otherwise \end{cases} \tag{2}$$

Where Pa= 0 or pb= 255, representing the unipolar impulse noise if it is salt and pepper noise or bipolar impulse noise, respectively. a=0 can be identified as (black), while b=255 can be identified as (white).



(2)

Figure 3: Salt and Pepper Noise

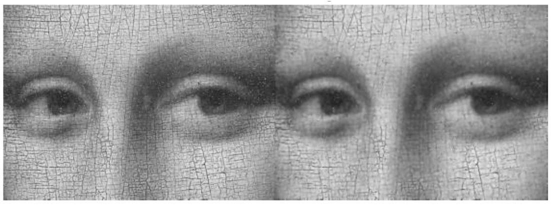


Figure 4: (a) Original Image (b) Salt and Pepper Noise

c) Poisson Noise

Poisson noise can be defined as shot noise. Photon counting in optical devices creates an electrical charge, which is discrete and can be interpreted as Poisson noise. Using optical devices in bright regions of the images via photon shot noises is known as the statistical quantum approach (Erkan, Gökrem, & Enginoğlu, 2018).

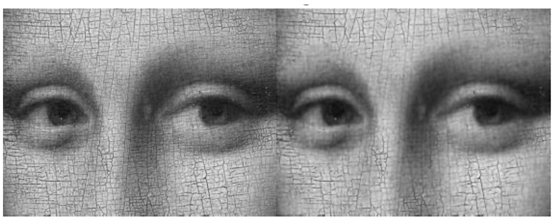


Figure 5: (a) Original Image (b) Poisson Noise

d) Speckle Noise

Speckle noise is also known as multiplicative noise. It corrupts and affects image quality. Speckle noise identifies pixel values that are nosiness pattern, deterministic, and random. The pixel value is calculated using the random multiplication value or via the application of the adaptive and non-adaptive filters (Joshi et al, .2015). These methods are all viable for the elimination of speckle-noise from images. The best technique for speckle noise removal is the mean filter method (Rachna Mehta, 2014). Speckle noise is dependent on the signal mean if the magnitude of the image pixel is high enough, which represents the high noise. The noise is multiplicative due to the recorded reflected signal. When transmitting the signal from the initial transmitting system to an object, it could be corrupted by the additive noise in the channel(S.V.Halse2, 2018). A digital image, represented as f(x,y), will be P(x,y) after being corrupted with multiplicative noise (noisy image), and can be mathematically characterized as:

$$P(x, y) = f(x, y) + \eta(x, y) f(x, y) \quad (3)$$

$$P(x, y) = f(x, y) + \eta(x, y) f(x, y) \quad (4)$$

Where *η (t)* is a random variable.

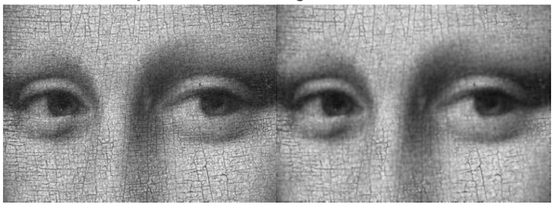


Figure 6: (a) Original Image (b) Speckle Noise

3. Types of Denoising Techniques

Image de-noising techniques are essential in the image analysis process. Removing noises from an image is a significant objective of image restoration.

The de-noising technique is also crucial for enhancing images during the processing stage. The main task of filtering involves identifying noises in an image that compromises image quality. De-noising algorithms can remove noises entirely from images without affecting details such as to preserve, edges, and smoothness (Mauro Barni, 2005; Hanumantharaju et al. 2013).

Noise removing techniques are categorized into linear and nonlinear techniques.

- ***Linear Techniques:***

Linear filters are used to remove specific types of noises. The original image with a mask represents low-pass filters. The output of a linear filter is based on the sum of two inputs. The filters also affect the quality of images as it blurs the sharp edges and merges the thin lines present in the image. An advantage of linear methods is its fast computations; however, they are not able to accurately preserve some details of the images(Elmustafa S.Ali Ahmed, 2015; Gao, 2018; Sakshi Tiwari1, 2014).

- ***Nonlinear Techniques:***

Nonlinear filters can preserve image details via the application of many techniques, especially the removal of non-additive noises. Nonlinear filters are considerably harder to use and design relative to their linear counterparts (Elmustafa S.Ali Ahmed, 2015; Gao, 2018; Sakshi Tiwari1, 2014).

A. Mean Filter

A mean filter is an average filter that can also be defined as a linear filter that is capable of removing noises from images. An average or mean filter minimizes variations of intensity between adjacent pixels to smoothen images. The mean filter analyzes the entire image and replaces problem pixels with common ones relative to the neighboring pixels (Sakshi Tiwari1, 2014).

B. Weighted Mean Filter

The weighted mean filter is a type of linear filter and is regarded as an alternative type of modified primary mean filter. Each pixel value operates its corresponding weights, while weights are channeled to the scanning window pixels, where the corresponding weights are used as a restoration value. Different filters can be used for calculating the given weight for the application of different parameters represented by the space starting from the position in the direction of the ordered statistics and the window pixel (Sakshi Tiwari1, 2014).

C. Trimmed Mean Filter

The trimmed mean filter is an advanced mean filter. The window pixel value of the trimmed means is replaced by testing the pixel in order to determine the trimmed mean value. The window pixel values are arranged in an ascending order based on the availability of all of the intensity values (Deepalakshmi et al. 2017). The first and last pixels are then removed from the order list. The restoration value for the deteriorated pixels is used as the mean value of the remaining pixels after the first pixel, and the last set is taken. After the last set of pixels are taken from an ordered list, the trimmed mean is used for the removal process ((Mauro Barni, 2005).

D. Median Filter

The median filter is a nonlinear digital filtering technique that is common in image processing. It is often used to remove noises from images and other types of signals. The median filter is useful for the removal of speckle noise and salt and pepper noise from corrupted images. The median filter affects only low noise densities. Higher noise densities produce unpreserved edge details of the original image and are regarded as a smooth transition between pixels (Gao, 2018; Hanumantharaju, Ravishankar, R Rameshbabu, & Aradhya, 2013).

E. Weighted Median Filter

The weighted median filter is regarded as a type of median filter. The standard median filter and weighted median filter operate similarly, except for the fact that the latter has an added weight component associated with each of its filter element. The calculation of the median value requires the number of sample duplications from its corresponding weights (Abas & Martinez, 2002).

F. Adaptive Median Filter

The adaptive median filter is a type of nonlinear filter. Relative to standard median filters, it is regarded as an advanced method. Usually, adaptive median filtering determines which pixels are affected by impulse noise in an image, then spatially process it (Dasgupta, 2014). The adaptive median filter distinguishes between corrupted and uncorrupted pixels by classifying them, then matching every pixel to its neighboring pixels in the image (Barni, Pelagotti, & Piva, 2005). The median value picks the corrupted pixels and replaces it, and ignores the uncorrupted pixels (Barni et al., 2005). At higher noise densities, the window size adaptive median filter method performs well. Most of the impulse noise is detected even at high-noise levels (Ahmad Odat, 2015).

G. Switching Median Filter

The switching median filter is based on the consistency information, such as those of the standard median and adaptive median filters. The mechanism of the switching median is based on two main procedures; pinpoint the corrupted noise and remove it from the image via the grayscale intensity value. (S. Esakkirajan, 2011b). Noise removal using the median filter utilizes window filter size makes it challenging to determine the correct median value because the correct value would be close to the real pixel value in the original image (SnehalAmbulkar, 2014).

H. Wiener Filter

The wiener filter is a nonlinear filtering technique that can be used to remove noises from corrupted images. This method uses a statistical approach. Both the noise and linear time-variant filters are considered outputs and are almost identical to the original images. The Wiener filter minimizes the desired process and estimated random process (Li, 2014).

I. Max-and-Mix Filter

The max-and-mix filter is similar to morphological filters, such as erosion and dilation. The max-and-mix filter takes into account the surrounding pixels in an image. It determines its value then store it as a corresponding output value based on the list of the surrounding pixels in the minimum value or maximum value of a filter list. After replacing each pixel in the image, an output value is created for an associated neighborhood. If the max-and-mix filter work alternatively, it can effectively remove the salt and pepper noise (Erkan et al., 2018).

4. Related Work

The current research on this topic involves developing new techniques for noise reduction. Restoration of images is a process of recovery of the original appearance of an image corrupted by acquisitions, transmission, and coding.

(Gao, 2018) proposed a boundary discrimination noise detection modification (BDND) algorithm and an adaptive median algorithm to remove noises from an image. This algorithm was added to the original image corrupted by noise. The BDND algorithm increased the actual window size by one step and incorporated the adaptive median algorithm to remove noises. The performance evaluation confirmed that the proposed modifications produced a sharp edge image and that the noise has been eliminated up to ~70% relative to the image produced using the BDND algorithm. The addition of the adaptive median algorithm led to increased time for the de-noising process when selecting an appropriate algorithm for noise removal from the image. The estimation was done using the proposed method of linear regression, and the algorithm window is increased to 15x15. The probability of obtaining a noise-free image will be higher compared to the conventional method. The proposed algorithm provided a superior PSNR value in the sequence of works mentioned above.

(Erkan et al., 2018) developed a new algorithm called the adaptive decision-based median, which was implemented to check whether the performance of the image improved or needed improvement. There were changes made in both the decision-based median algorithm and the adaptive median filter, which are the window size increased by2 in the horizontal and vertical directions, and it increases continually until the size of the window is maximized. The left neighborhoods' pixel value replaced the decision-based median filtering. This new algorithm was compared with other algorithms, and it produced better results in terms of removing noise from corrupted images.

(Mauro Barni, 2005) developed a system based on the median algorithm in order to remove highly colored corrupted images with salt and pepper noise. The median algorithm efficiently affected and enhanced low noise levels in an image. On the other hand, the details of colored images have been preserved. The result was obtained after the proposed techniques are tested and examined in order to give better outcomes based on the evaluation of the quality measurements factor such as MSE and PNSR are considered image enhancement factors.

(Elmustafa S.Ali Ahmed1, 2015) proposed and evaluated the median algorithm to detect and eliminate an image deteriorated by salt and pepper noise. The simulation added the salt and pepper noise algorithm to evaluate the effect of the variation in window size after using the median filter to gray images and from the RGB images, and also by using different noise densities of 20 - 70%. The performance was analyzed based on the median algorithm in gray images and the RGB images. The median algorithm and effects of the grayscale and RGB images were compared. The experimental results confirmed that the median algorithm effect noise removal in the images based on window sizes. Low level of window sizes, such as 3x3, performed better in low noise densities. However, increasing noise density lowered the effectiveness of noise removal from corrupted images and vice versa in the case of window size of 9x9. The performance of the proposed algorithm performed better, even in high-noise density environments.

(Arabinda, 2015) developed an algorithm to remove the salt and pepper noise from an image in two phases. Researchers confirmed that the pixels in the first phase are similar to the degraded pixel by utilizing the adaptive median algorithm. The second phase is a specific technique that is used at noise pixels only in order to reconstruct the image for the next step. The developed algorithm is an important improvement over those reported in the literature. The adaptive techniques or nonlinear filters are only the reconstructed image and is capable of removing noise and preservation edge.

(SnehalAmbulkar, 2014) developed an algorithm called the Comprehensive Median. The Comprehensive Median algorithm works by taking the median lengthways rows and columns. The standard median filter in the corrupted image can be enhanced using the comprehensive method. An image with better quality is produced using the Comprehensive Median algorithm based on the standard median. When the mask size is smaller, such as 3x3, it produces a better image quality. The comparison performed using a standard median filter indicated that the comprehensive median algorithm creates a good quality image; however, the algorithm suffers from time constraints and is costly.

(Barni et al., 2005) proposed an algorithm implemented into different types of noises and de-noising algorithms. The image restoration and noise removal from the images are expected to enhance the images. Image filtering is more concerned with restoring useful information from the original image as much as possible. The implementation techniques on the image show enhancement to the performance of the quantitative measure. Added or degraded types of noise on images will show how the removed or minimized noises from images, and many other methods for noise reduction or image enhancements were considered.

(Arabinda Dash, 2015)proposed an enhanced decision-based technique that eliminates the grayscale images that were strongly degraded by salt and pepper noise by making minimizing/maximizing the pixels intensity noises. Their technique employs and manipulates all of the neighboring values and compares them to the classical median filter, which resulted in better images. The methodology depends on the use of the median technique on the corrupted de-noising pixels only, or on the neighboring pixels using the mean to manipulate the neighboring pixel values. The proposed algorithm and the classical median algorithm were utilized to remove the salt and pepper noise from the images while conserving the edges and features present in the image.

(A.Srinagesh, , 2014,) proposed an algorithm for the removal of the noise pixels from an entire image (ADBUTMF) that performs better than algorithms such as the Median Filter (MF), Decision Based Algorithm (DBA), Modified Decision Based Unsymmetric Trimmed Median Filter (MDBUTMF), Progressive Switched Median Filter (PSMF), and Modified Decision Based Algorithm (MDBA). The proposed ADBUTMF algorithm is effective for the removal of salt and pepper noise from corrupted images (Rachna Mehta, 2014). It reported better results relative to other reported methods, even in the case of high-density noises of up to 80 - 90%. The proposed method was tested using multiple grayscale and color images, and resulted in better PSNR and IEF, especially at higher noise densities.

(Sukhwinder Singh1, 2014) developed a new algorithm using the modified adaptive median filter and the statistical algorithm Rank Order Absolute Difference (ROAD) for the detection and removal of the salt and pepper noise from corrupted images. The proposed algorithm consists of two main stages, the first determines and evaluates how a particular pixel is different from other similar pixels, followed by using the data from the previous step to detect the salt and pepper noise using the adapt filtering window. The performance evaluation used different grayscale images that were degraded by the salt and pepper noises.

In the proposed filter, various experiments were conducted by using grayscale images of corrupted salt and pepper noise as test images. The testing and evaluation results confirmed that the proposed algorithm performed better than other algorithms at low and high noise density values. The subjective evaluation conducted on the proposed algorithm compared to other de-noising methods confirmed that it is capable of preserving details in the images as well.

(Lalit Kumar, 2018) proposed an advanced median trimmed filter for the removal of salt and pepper noises. The simulation used the proposed algorithm to remove salt and pepper noise by increasing the value of the PSNR. Comparing the base paper and proposed methods' analytical results confirmed that the latter is superior. Researchers detailed their methods and how the salt and pepper noises were removed from the original data using a specific filter. The algorithm was executed using data collected using a webcam. Salt and pepper noises have many example cases and are present in many types of images at varying percentages of 10 - 70% noise density level. The evaluation parameters include MSE, PSNR, and IEF. PSNR and MSE calculated how the salt and pepper noise was efficiently removed from the original data. The tests producing the highest value of the PSNR would be considered the best.

(S. Saranya, 2014) proposed a noise removal algorithm modified decision based median filter to remove noise from corrupted grayscale and color images. The proposed algorithm was compared with existing algorithms such as Adaptive Median Filter (AMF), Switching Median Filter (SMF), Modified Decision Based Median Filter (MDBMF), and Decision Based Median Filter (DBMF). Image processing operations used modified decisions based median algorithm to enhance the image for further processing. The experimental results confirmed that the proposed algorithm, compared to the other methods, can quantitatively perform better relative to existing filters such as AMF, SMF, and DBA. Decision-based filter reported lower PSNR value in the case of noisy images. In future works, it is suggested that nonlinear filter (MNF) be applied for modifying noise removal from images based on the quantitative parameters, such as PSNR and MSE.

(1Ankita, 2016) proposed a decision-based filtering technique for removing corrupted noise to produce better images. The proposed algorithm is a combination of K-means and PCA. Comparison analysis confirmed that the proposed filter reported better results relative to other filtering techniques. Noise levels were lowered from the use of filtering or increasing the value at a particular set of functions, such as edges. The Adaptive Wiener filter removes the Gaussian noise by implementing a low pass filter noise to decrease high-frequency details to produce a smoothed and sharp image. A hybrid median filter and combination of k-means, PCA, and decision-based filtering techniques mitigated the limitations inherent in hybrid filters and reported better resulted relatively to hybrid filters based on their respective PSNR values. The hybrid median filter reported excellent results, but the decision-based technique reported the best results.

(Brijnandan Chaturvedi 2014) proposed a combined median, adaptive median, and weighted median algorithms to decrease salt and pepper noise from an image. However, this approach could decrease image quality. They used the nonlinear median algorithm as it is suitable for low noise density in small window sizes, such as 3x3, where pixels will blur and get damaged in high noise densities and increased window sizes. They also used the adaptive median algorithm to pinpoint corrupted pixels and replace them using the median algorithm, while retaining the undamaged pixels as-is. The adaptive median algorithm provides the most significant window size at high-level noises (fitting issues). The weighted median algorithm was used to remove the grayscale and color image noise as it is the best algorithm for removing the high level of noise. The experimental result reported the best PSNR relative to the quality measurement evaluation SMF and AMF that is comparable to that of other noise removal algorithms.

(S. Esakkirajan, 2011a) proposed a combination of median filters with multiple options. Different types of noise techniques and various types of noise reduction techniques were described and compared, such as the simple adaptive median filters (SAMF), adaptive median filter (AMF), median filter (MF), and their advantages over one another elucidated. The evaluation of the proposed algorithm reported better results in the context of the quality measures of the PSNR. The SAMF increased the quality measures in high noise density value; however, it should be pointed out that its performance decreased when dealing with low noise density values. Also, both the MF and AMF reported better results compared to that of the SAMF.

(Nisha, 2015) proposed an algorithm for noise reduction of images corrupted by salt and pepper noises. Decision-based algorithms were successfully used to remove impulse noises. The proposed algorithm reported better experimental results compared to the other algorithms. Discrete wavelet transforms techniques were used to remove salt and pepper noise from corrupted images. Linear and nonlinear techniques were proposed and implemented for the removal and reduction of noises from images using linear and nonlinear filtering techniques. A general, nonlinear algorithm reported better results and performed better in the removal of salt and pepper noise. Linear algorithms also reported excellent performances.

(G. Baby Joice1, 2017) pointed out that image restoration is essential due to its associated with image quality. It can be used to recreate or remodel an image from noises. Image noise is the differentiation of brightness or unwanted signals and can be used to destroy most of the image. Images can be destroyed by various types of noises such as Salt and Pepper noise, Gaussian noise, and Poisson noise. Different techniques can be used to remove noises and modify/restore images without sacrificing its resolution. In image restoration, implemented algorithms include smoothing, sharpening, and edge detection. This paper focuses on the analyses and de-noising of salt and pepper noise using filtering techniques. The mean and median filterings for image de-noising algorithms were analyzed. The algorithms are compared based on their respective MSE and PSNR values before and after de-noising. The comparative studies confirmed that the mean and median filtering algorithms are suitable for specific environments, but is not applicable for entire environments due to the challenge in image recovery from the presence of noises.

(Deepalakshmi R1, 2017) proposed an algorithm for noise removal from corrupted images. These techniques depend on the presence of noises in images. Some de-noising techniques include mean filter, median filter, mean-median filter, weighted median filter (WMF), standard median filter (SMF), super mean filter (SUMF), and the decision based median filter (DBMF). Among the de-noising techniques, the WMF reported satisfactory results for de-noising images as it preserves the edges in the case of high-level noises. Various mean filter techniques are suitable for decreasing salt and pepper noises from an image. The Modified Mean-Median filter was introduced as a new filter for the removal of efficient noises from images. The SMF was used to remove impulse noise to overcome the Mean-Median filter. The SUMF was used to remove noises from high-density digital images. WMF removes the discontinuity in underlying regression function, while the Decision Based Filter is efficient for de-noising at lower levels. However, it fails in the medium filter and at high densities due to the restored pixel of the selected window where the w median value is that of a corrupted pixel. The new WMF was introduced to overcome this problem, which reported satisfactory results in reducing high-level salt and pepper noises.

(U˘gur ERKAN1, 2018) developed a new algorithm called based-on –pixel-density-filter (BPDF), which effectively removes salt and pepper noises from a degraded image. This algorithm works via a two-step process: first, it determines if the current pixels noise-damaged, then it deals with the noised pixels via an adaptive window size, which decides to locate the noised pixels at the center of the mask. The proposed system selects the most repeated uncorrupted pixel within the window as a new pixel and re-located it. The experimental results used 18 grayscale images and evaluated them using the PSNR. The proposed algorithm was compared with algorithms such as (SSIM) structural similarity, and (IEF) image enhancement factor. Adaptive fuzzy filter (AFM), decision-based algorithm (DBA), standard median filter (SMF), adaptive median filter (AMF), decision-based algorithm (DBA), progressive switching median filer (PSMF), noise adaptive fuzzy switching median filter (NAFSM), modified decision-based unsymmetrical trimmed median filter (MDBUTMF), and based on pixel density filter (BPDF). The experimental results confirmed its effectiveness at low and medium noise densities relative to the other mentioned techniques.

(Joshi2, 2015) proposed an adaptive median algorithm for the restoration of severely corrupted grayscale images of noise. The mechanism of the adaptive median filter is made up of two main processes: first, the pixels corrupted by the salt and pepper noise are determined of, followed by automatically increasing the window size until it correctly identifies the noised pixel that was corrupted by salt and pepper noise and replace them with suitable median value pixels. The method used various types of grayscale images at high and low noise densities. The experimental results confirmed that the proposed algorithm is superior to standard median filter (SMF), weighted median filter (WMF), switching mean median filter

(SMMF), while the evaluation parameter uses MSE, Structural Similarity Index (SSIM), and PSNR. It was also confirmed that combined algorithms improve de-noised techniques.

(shilpa Rani, 2020) proposed the Lucy Richardson and wiener to remove noise and reduce blurs in images from a grayscale image that were corrupted by different noises. The mechanism of Lucy and wiener algorithms utilize several types of color and grayscale images with various noise densities to deblur the noise image. The devaluation and results obtained post-literature survey on various image deblurring techniques confirm that the results by this approach are superior based on the MSE and PSNR parameters.

(Bhaskara Rao Jana, 2019) proposed the modified trimmed filtration algorithm, which is a form of the median algorithm. Different noises can degrade grayscale images. The modified trimmed filtration algorithm selects the 3X3 dimensional window as its central component, and specify it as a noisy and running pixel. The algorithm replaces the mean of the 9 elements' value, as the big pixel tends to be not 0's or 255's, or in other words, it operates pixel-by-pixel. Simulation results show that the proposed modified trimmed algorithm reported excellent results relative to those of AWMF, MDBUTMF, and DBUTVF. The evaluation results obtained by analyzing different images using quality testing parameters confirmed the higher PSNR with reduced MSE for different noise densities. The modified trimmed algorithm showed excellent characteristics and is capable of enhancing the quality of an image and preserving its features post-noise removal.

(S. Abdul Saleem, 2016) proposed an effective algorithm called adaptive median, which removes the adaptive median algorithm works for both corrupted grayscale and color images with high densities of up to ~90% with impulse noises and can preserve details while also enhancing image quality. The methodology of the proposed algorithm depends on selecting the correct neighborhood values to obtain a useful median per window using the 3x3 overlapping window for signal filtration. The experimental results confirmed the effectiveness of the adaptive median algorithm and reported better performance relative to the quantitative image metrics such as the MSE, PSNR, IEF, RMSE Time, and SSIM. It also performs better relative to VMF, DBA, SMF, and ROAMF. The adaptive median algorithm is faster than the ROAMF, as it uses a 3×3 small and fixed window size. The performance of the proposed active median filter was evaluated using MATLAB.

5. Discussion

This paper detailed the different algorithms and methods of signal removal algorithm. Generally, noise algorithms corrupt images and decrease its overall quality. There are four types of noise; Gaussian Noise, Salt and Pepper Noise, Speckle noise, and Poisson Noise (Arabinda et al. 2015; Dasgupta et al. 2014; G. Baby et al. 2017). (Hanumantharaju et al. 2013; S. Esakkirajan et al. 2011).

These noises are unique and distinguishable. Gaussian noise is a normal noise, and can be designated and characterized using the (Probability Density Function) PDF, and is the mathematically correct approximation of real-world developments (Sukhwinder et al. 2014; S. Abdul Saleem, 2016). Its mean value is zero and its variance 0.1, and it takes 256 as its gray level in terms of PDF (Probability Density Function) (shilpa et al. 2020; Rachna Mehta, 2014). Salt and pepper noise mainly deals with random noise corrupting color and grayscale pixel values. Both values represent positive and negative impulses. Its methodology involves substituting the minimum value pixels with maximum value. The white spots means (salt, 255), which represent the positive impulses, while the black spots mean (pepper, 0), representing negative impulses in an image (S. Esakkirajan, 2011; S. Abdul Saleem, 2016; S.V.Halse, 2018). In the case of speckle noise, every pixel value is calculated using random multiplication value or the application of the adaptive and non-adaptive algorithms. The best approach towards removing degraded noises from images is the application of mean algorithms (Rachna Mehta, 2014; Dasgupta et al. 2014). The last type of noise is Poisson noise, caused by electronic interactions, where the discrete electrical charge in optical devices is interrupted (shilpa Rani, 2020; (Ugur ERKAN, 2018; Bhaskara et al. 2019).

Restoration is an essential step for noise removal from an entire image. Researchers proposed various noise reduction algorithms for noise removal from a degraded image and increase image quality by smoothing the entire image. The de-noising algorithms can be classified into two main groups; the first are linear algorithms, which are fast computing and used by convolving algorithms or smoothing operation and preserving edge to remove specific types of noises, such as the standard median filter (SMF), where it removes thin lines and blurs image details even at low noise densities (Rachna Mehta, 2014), Vector Median Filter (VMF) to preserve the image details, Weighted Median Filter (WMF) and center Weighted Median Filter (S. Abdul Saleem, 2016) (CWMF) to modify median filters to preserve image details, Progressive Switching Median Filter (PSMF), obtained by combining the median filter with an impulse detector and an impulse corrector (Dasgupta et al. 2014; Rank Ordered Adaptive Median Filter (ROAMF) (Sukhwinder Singh1, 2014 ; S. Esakkirajan, 2011) it keeps the image details of highly corrupted digital images by switching the filtering of only corrupted signals with a mid-ranking value chosen from a neighborhood that varies adaptively with the quantum of impulse noise, Modified Decision Based Median Filter (MDBMF), Decision Based Median Filter (DBMF) and Switching Median Filter (SMF G. et al. (2017) Nisha et al. (2015) S.V.Halse et al. (2018), adaptive fuzzy filter (AFM), decision-based algorithm (DBA), decision-based algorithm (DBA), noise adaptive fuzzy switching median filter (NAFSM), modified decision-based unsymmetrical trimmed median filter (MDBUTMF) and based on pixel density filter (BPDF). The second group is nonlinear algorithms that can preserve details of images by applying algorithms to remove specific types of noise that are not additive (Nisha et al. 2015; Dasgupta, 2014; S.V.Halse et al. 2018). There are many discussing several methodologies for noise removal from digital images, detailed below:

The methodology is mainly implemented for de-noising, image smoothness, sharpening, and edge-preserving of images, and it can be seen that the operated multiple images at different window sizes such as 3x3, 5x5, 7x7, and 9x9 and also utilized various noise density values of 10 - 90% (Ugur ERKAN, 2018; Bhaskara Rao Jana, 2019; shilpa Rani, 2020).

Different proposed algorithms were applied to remove impulse noises from digital images such as median, weighted mean, trimmed mean, mean, and switching median. Image quality enhancement involves selecting the most suitable window size and noise density for implementation in the next stage. After that, the experimental results of using low-level window size and executing high-level window size were compared. The performance of the proposed active median filter has been evaluated using MATLAB (Bhaskara Rao Jana, 2019). The evaluation involved testing the algorithms using a standard typical image reported in the literature and using objective image quality measurements such as PSNR and MSE.

6. Conclusion

Noises occur due to errors generated by noisy sensors while sending and reserving data. This paper details a large number of techniques were proposed for noise removal and image preservation while doing so. For images corrupted by noises, linear or nonlinear filter methods can be used to decrease noises. The pros and cons of recent linear noise removal methods were discussed and provided a comparison between most of recent used methods. The experimental results confirmed the effectiveness of using quantitative image measurements, such as MSE, PSNR, IEF, and RMSE, evaluated using MATLAB software. Most of the techniques in testing and evaluation reported better results, and future endeavor can focus on developing techniques to increase the accuracy rate of noise removal from images.

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