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# Review of Image Noise Remove Techniques

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***Abstract:*** *In various fields and applications use of images are becoming is popular like in field of medical, education etc. But during image acquisition process noise will be inevitably introduced in the image that causes problem. Another problem that arises after denoising process is the destruction of the image edge structures and introduction of artifacts. To get rid from this there are several techniques proposed by authors for image denoising as well as for edge preservation. In this paper, we aim to provide a review of some of those techniques that can be used in image processing for noise removal. The aim of this review paper is to provide some brief and useful knowledge of available noise removing techniques and hence optimal technique according to their needs.*

***Keywords:*** *Image Denoising; Salt-and-pepper noise; Gaussian noise; Gaussian distribution; MSE; PSNR; Thresholding.*

## 1. INTRODUCTION

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Any form of signal processing having image as an input and output (or a set of characteristics or parameters of image) is called image processing. In image processing we work in two domains i.e., spatial domain and frequency domain. Spatial domain refers to the image plane itself, and image processing method in this category are based on direct manipulation of pixels in an image [2] and coming to frequency domain it is the analysis of mathematical functions or signals with respect to frequency rather than time. The principal sources of noise in digital images arise during image acquisition and/or transmission [2]. It can be produced by the sensor and circuitry of a digital camera or scanner. Noise degrades the image quality for which there is a need to denoise the image to restore the quality of image. Hence, first the question arises is what is noise?

Definition: Image noise means unwanted signal. It is random variation of color information and brightness in images, and is usually an aspect of electronic noise. It is an undesirable by- product of image capture

The rest of this paper is organized as follows. Section 2 outlines the image denoising including types of noise and some noise filtering techniques. Then, Sections 3rd and 4th discuss, in brief the need for edge preservation and detection and literature review of the denoising techniques in each domain. The last section consists of the conclusion.

## 2. PROPOSED WORK

### A. Gaussian noise

The One of the most occurring noise is Gaussian noise. Principal sources of Gaussian noise arise during acquisition e.g. sensor noise caused by poor illumination and/or high temperature, and/or transmission e.g. electronic circuit noise. Gaussian noise represents statistical noise having probability density function (PDF) equal to that of the normal distribution, which is also known as the Gaussian distribution.

The probability density function $p$ of a Gaussian random variable is given by

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

Where represents the grey level the mean value and the standard deviation [1] The standard model of this noise is additive, independent at each pixel and independent of the signal intensity, caused primarily by thermal noise. The mean of each distributed elements or pixels of an image that is affected by Gaussian noise is zero. It means that Gaussian noise equally affects each and every pixel of an image.

**B. Salt and pepper noise**

The Fat-tail distributed or "impulsive" noise is sometimes called salt-and-pepper noise. Any image having salt-and-pepper noise will have dark pixels in bright regions and bright pixels in dark regions. In salt-and-pepper noise corresponding value for black pixels is 0 and for white pixels the corresponding value is 1. Hence the image affected by this noise either have extreme low value or have extreme high value for pixels i.e., 0 or 1.Given the probability r (with 0<= r<=1) that a pixel is corrupted, we can introduce salt-and-pepper noise in an image by setting a fraction of r/2 randomly selected .pixels to black, and another fraction of r/2 randomly selected pixels to white. This type of noise can be caused by analog-to-digital converter errors, bit errors in transmission, etc. Elimination of salt-and- pepper noise can be done by using dark frame subtraction and interpolating around dark/bright pixels.

**C. Shot Noise**

In the lighter parts of an image there is a dominant noise from an image sensor which is typically caused by statistical quantum fluctuations, that is, variation in the number of photons sensed at a given exposure level called photon shot noise. Shot noise follows a Poisson distribution, which is somehow similar to Gaussian.

**D. Quantization Noise**

This noise follows an approximately uniform distribution and also known as uniform noise. Quantization means the process of dividing, hence the noise caused by quantizing the pixels of a sensed image to a number of discrete levels is known as quantization noise. Though it can be signal dependent, but if dithering is explicitly applied it will be signal independent.

**E. Anisotropic Noise**

Some noise sources show up with a significant orientation in images. For example, image sensors are sometimes subject to row noise or column noise [1].

## 3. NOISE FILTERING TECHNIQUES

**A. This Removing Noise by Linear Filtering**

Linear filtering is use to remove certain types of noise. Averaging or Gaussian filters, are appropriate for this purpose. For example, an averaging filter can remove noise or grain from a photograph by replacing each pixel value with the average value of its neighborhood pixels. By this local variations caused by grain are reduced.

**B. Removing Noise by Median Filtering**

Median filter is a non-linear filter which is similar to an averaging filter. In this the value of an output pixel is determined by replacing the value of each corresponding pixel by the median of the neighborhood pixels, rather than the mean. The median is much less sensitive than the mean to outliers (extreme values). Median filtering is therefore better to remove outliers without reducing the image sharpness.

**C. Removing Noise by Adaptive Filtering**

A Wiener filter (a type of linear filter) is applied using wiener2 function to an image adaptively, tailoring itself to the local image variance. Whenever there is large variance, wiener2 performs little smoothing and vice versa. This approach produces better results than linear filtering. The adaptive filter is more selective than a comparable linear filter, as it preserves the edges and other high-frequency parts of an image. In addition, there are no design tasks; the wiener2 function handles all preliminary computations and implements the filter for an input image. wiener2, however, does require more computation time than linear filtering.

## 4. EDGE DETECTION

As we have many techniques and filters to remove noise (some of them are discussed above) there is a problem of loss of edge information. After denoising edge information will be lost hence we need to preserve edge information and at the same time preserve the edges. Edge features are an important component of image under study. Therefore, edges should be well preserved during image noise removing.

The most common and widely used approach for edge detection is canny edge detection algorithm for canny edge detection runs in five steps:

1. Smoothing: Blurring of the image to remove noise using filter.

2. Finding gradients: The edges should be marked where the gradients of the image has large magnitudes.

The edge detection operator (Robert, Prewitt, Sobel for example) returns a value for the first derivative in the horizontal direction (Gx) and the vertical direction (Gy). From this the edge gradient and the direction can be determined:

$$\mathbf{G} = \sqrt{\mathbf{G}_x{}^2 + \mathbf{G}_y{}^2}$$

3. Non-maximum suppression: Only local maxima should be marked as edges.

4. Double thresholding: Potential edges are determined by thresholding.

5. tracking by hysteresis: Final edges are determined by suppressing all edges that are not connected to a very certain (strong) edge.

## 5. LITERATURE REVIEW

To find different applications in image segmentation clustering-based segmentation technique is used [3]. In image processing method clustering algorithm is widely used segmentation method but due to occurrence of noise during image acquisition, this might affect the processing results. In order to overcome this drawback, algorithm called Denoising- based (DB) clustering algorithm presented three variations namely, Denoising-based-K-means (DB-KM), Denoising- based-Fuzzy C-means (DB-FCM), and Denoising-based- Moving K-means (DB-MKM) [3]. This algorithm was proposed to minimize the salt-and-pepper noise without degrading the fine details of the images during the segmentation process. These methods incorporated a noise detection stage to the clustering algorithm, producing an adaptive segmentation technique specifically for segmenting the noisy images [3]. Conventionally, in case of occurrence of Salt-and-Pepper noise in images we have to apply a pre- processing task like filtering before segmentation. To tackle this problem, an adaptive clustering-based segmentation technique by incorporating the noise detection stage for segmenting noisy images was proposed. The inherited noise detection behavior improved the segmentation results by only selecting noise-free pixels for the process of segmentation. The result of this proposed algorithm was better when compared with conventional algorithms because of the inclusion of the noise detection stage in its process. Proposed algorithms were able to remove low density of salt-and-pepper noise (i.e., up to 50%) during the segmentation process. [3].

In study of coherent imaging systems for e.g. ultrasound and laser imaging, multiplicative noise (also known as speckle noise) models are central. With respect to the standard Gaussian additive noise scenario these models have two additional layers of difficulties: 1) the noise is multiplied by (rather than added to) the original image; 2) the noise is not Gaussian, with Rayleigh and Gamma being commonly used densities [4].In this paper author performed a set of experiments and presented that their proposed method named MIDAL (multiplicative image denoising by augmented Lagrangian), yields state-of-the-art results in terms of speed as well as in denoising performance.

In this paper [4], they addressed the (unconstrained) convex optimization problem results from the –look multiplicative model formulated with logarithm of the reflectance. An optimization algorithm is proposed with these respective building blocks

Author of this paper [5] proposed a recursive filter, called the Cluster-based Adaptive Fuzzy Switching (CAFSM) for removing impulse noise from digital images. This filter is composed of a cascaded easy to-implement impulse detector and a noise filter

The CAFSM filter outperforms other state-of-the art impulse noise filters in terms of subjective and objective qualities in the filtered images when applied recursively and iteratively and shows excellent restoration results in denoising color images [5]. In this paper [6] authors proposed a general methodology (PURE-LET) for denoising images that are corrupted by mixed Poisson-Gaussian noise. This methodology is used for designing and optimizing a wide class of transform domain thresholding and gives a competitive solution for fast and high-quality denoising of real fluorescence microscopy data

Adaptive filters that are well-known as the filters with the coefficients adjusted by the adaptive algorithms are widely used in various applications for achieving a better performance [7]. The dimension of the adaptive filters varies from application to application. The 1-D adaptive algorithms are usually classified into two families. One is the least-mean- square (LMS) family; the other is the recursive-least-square (RLS) family. The algorithms in the LMS family have the characteristics of easy implementation and low computational complexity [7].

The 2D-LMS adaptive filter [8] is essentially an extension of its one dimensional counterpart. The 2DLMSis an attractive adaptation algorithm because of its simple structure, but this algorithm is highly sensitive to Eigen value disparity, and its convergence speed is slow that is not appropriate in many applications. Therefore, to overcome this problem, the 2D normalized NLMS (2D-NLMS) algorithm was proposed. In this algorithm, the influence of the magnitude of the filter input on the convergence speed was considered. The 2D adaptive FIR filters which was based on affine projection algorithm (APA) was firstly introduced in [9]. In this algorithm the positions of projection vectors can be selected freely, and the performance is improved especially when the input data is highly correlated. Unfortunately, this improvement comes at the expense of a higher computational complexity

The 2Drecursive least squares (2D-RLS) algorithm was proposed in [10-12]. Whereas the computational complexity of one dimensional RLS is high, when we extend the one dimensional to 2D, the computational complexity is increased. The 2D-RLS has good performance in many applications, but the cost that we have to pay to enjoy its abilities is so expensive.

In 1981, Clark [13] proposed the block least-mean-square (BLMS) approach which is an application extended from the block processing scheme proposed by Burrus [14].

In such an approach, the computational complexity is dramatically reduced. In addition, the linear convolution operation can be accomplished by parallel processing or Fast Fourier Transform (FFT).In 2D adaptive filter algorithms, the small variation of the step-sizes can produce an undesirably large change in adaptation speed and accuracy. Hence the optimal step-size selection is important in different applications. This selection is usually obtained by trial and error. Furthermore, an adaptive system with a constant step- size cannot appropriately adjust its parameters. To overcome this problem, the time-varying step-size technique was proposed in [15].

The one dimensional SM-NLMS algorithm and the SM-APA were proposed in [16] and [17], respectively. To reduce the computational complexity in 2D applications, they introduced two new 2D-SMadaptive algorithms which are an extension of their one dimensional counterpart. The simulation results of the2D-SM-NLMS and 2D-SM-APA show that these algorithms have good performance in elimination of noise in digital images.

In the classical adaptive filters the filter coefficients are fully updated. To reduce the computational complexity, other adaptive filter algorithms where introduced where the filter coefficients are partially updated. Based on this approach the filter coefficients which should be updated are optimally selected during the adaptation. The one dimensional selective partial update NLMS (SPU-NLMS) and SPU-APA are important examples of these adaptive filters [22]. To reduce the computational complexity of conventional2D-NLMS and 2D-APA algorithms, we extend the SPU approach to 2D structure to establish of the 2D-SPUNLMSand 2D-SPU-APA. In the applications of digital image processing, two dimensional(2-D) adaptive algorithms such as TDLMS, TDBLMS,OBA, OBAI, and TDOBSG are usually used [9-12].Most of the 2-D sequential adaptive algorithms in the literature use a constant convergence factor for updating the 2- D coefficient matrix, Two-Dimensional Block Least Mean Square Algorithm (TDBLMS).A second algorithm which uses a convergence factor that is the same for all the 2-D coefficients at each window iteration, but is updated at the next window iteration is also proposed. This is called the Two- Dimensional Optimum Block Algorithm (TDOBA). The convergence factor in this case is computed from readily available signals. It is shown that the speed and accuracy of adaptation are greatly improved when compared to the TDBLMS algorithm. The two-dimensional blocks of data can be processed in two ways as using disjoint windows and using shifting or overlapping windows. Furthermore, in the case of non stationary transfer functions i.e. transfer functions that change slowly over the two-dimensional signal, an accurate tracking of the transfer function over the two-dimensional signal can take place only when sliding blocks of data are used [16].Either in TDLMS or TDBLMS, the convergence factors are constant. Instead of the constant convergence factors in TDLMS and TDBLMS, the space-varying convergence factors are used in OBA, OBAI, and TDOBSG for better convergence performance. However, such space-varying convergence factors will increase the computational complexity due to the computations for the new convergence factor of next block.

## 6. CONCLUSION

The In this paper, we explored some of the denoising techniques for image denoising. Here we analyzed and present a literature review of some of the proposed denoising techniques that will be useful for the users by getting a brief introduction of these techniques so that they can make use of any one of them if needed. Image processing is a widely growing field as many of the nowadays applications are making use of it. Therefore, there is also a need of image denoising techniques due to introduction of noisy elements during image acquisition. Hence, our concern is to provide a collective brief review of some of these techniques in a single paper to provide ease to the image users.

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