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Image Denoising Techniques: An Literature Review

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ABSTRACT: Now-a-day's Digital Image Processing assumes an indispensable job in our day by day works too. Quality of images plays a crucial role, for example in the medical field. Medical Fundus images are used for detecting eye-related diseases. The primary objective of Denoising an image is not only to remove noise but also to preserve the image details as much as possible. In the present era, visual information is very significant. Since visual information transmitted in the form of digital images is becoming the most important technique of communication. Therefore, Image Processing plays a very vital role in progressive accomplishments wherever the images are used. Digital image processing deals with digital images such as computerized images, MR images, etc., and these images must be in precise shape. However, during the transmission of images, they often find corrupted with noise. To overcome this issue, various noise removal methods have been developed for eliminating noise and preserving edge details in the image. In that case, every method has its benefits and drawbacks. The initiative behind these methods is to acquire superior results in terms of quality and elimination of different noises. This paper presents a review of some significant work in the domain of image denoising.

KEYWORDS: Gaussian noise, Salt and pepper noise, impulse noise, spatial filters, Wavelet transform, Image denoising

I. INTRODUCTION

Digital images play a very significant role in applications like television, MR Imaging, Computed tomography, geographical information system, and astronomy. Collections of information gathered by image sensors and other devices are normally polluted by noise. Moreover, noise may occur owing to transmission errors and compression. Hence, denoising is often desirable and is the first step to be performed before image data is investigated and processed. With recent advances in image technology, image denoising has found renewed interest for researchers. Image denoising is one of the elementary challenges in the domain of image processing, where the fundamental objective is to estimate the original image by curbing noise from a noise-polluted version of the image. Image noise may be caused by various intrinsic (sensors, image capturing devices, etc.) and extrinsic (environment) surroundings which are frequently not feasible to evade in practical circumstances. Therefore, image denoising plays a significant role in a broad range of applications such as image restoration, visual, tracking, image registration, image segmentation, and image classification, where acquiring the original image content is vital for reliable performance. The objective of de-noising is to eliminate the noise at the same time, retaining the maximum possible significant signal information of an image. Various types of images accede to different kinds of noise and different noise representations are used to present different noise types. The denoising process tends to be issue-specific and depends upon the type of image and noise model [1]. Noise is generally modeled as Gaussian noise (Normal), Uniform noise, and Impulse noise (salt and pepper noise) in [2, 3]. The impulse noise is of two kinds, Fixed valued and random valued. The fixed valued impulse noise is too called salt and pepper noise which can have a value of either 0 or 255. Here 0 denotes absolute black and 255 denotes absolute white on a gray scale image. The random valued impulse noise can have any value from 0 to 255; therefore, its elimination is very significant and complex. Image de-noising is a vital pre-processing phase for image analysis. The image denoising process yet remains an imperative challenge for researchers since; denoising process eliminates the noise however, introduces artifacts and also causes blurring. In this paper various methods of image noise reduction techniques are discussed. This paper is presented in five sections including the introduction. In section II noise model for different types of noise is described. Section III presents the brief idea regarding the evolution of image denoising methods. Lastly, section V gives the conclusion of the work.

II. LITERATURE REVIEW

[8] In this paper, In denoising problems, signal and noise can be separated in the process and hence elimination of noise becomes easier. It is proposed in this paper that when a nonlinear MF is utilized in multiresolution surroundings, once incomplete resolution after which with 1/2 resolution, denoising will become extra best. This technique is nonlinear processing and is found to be useful in reducing not only impulse noise but also Gaussian and Speckle noise. Further, it's also proposed that the use of a nonlinear AMF produces a greater fascinating picture with enhanced denoising.

[9] In this paper, we advise an MF and adaptive wavelet thresholding shrinkage approach for ID. The noisy image is passed through pre-processing MF to remove the noise and two-level DWT is applied which is passed through post-processing MF to remove noise. The IDWT is carried out to reconstruct the image. The picture worth is measured in terms of the PSNR and is determined that the proposed scheme obtains higher PSNR as compared to the existing method.

[10] In this paper, Image denoising has been a nicely-studied difficulty for imaging structures, specifically imaging sensors. Despite super progress within the satisfaction of denoising algorithms, chronic challenges continue to be for an extensive elegance of general pictures. In this work, we present a new concept of collection-to-collection similarity. This similarity degree is an effective technique to assess the content similarity for pictures, mainly for part information. The method differs from traditional IP strategies, which rely upon pixel and block similarity.

[11] In this paper, according to the extraordinary function of the UV detection picture, a Partial Differential Equation of Adaptive Median Filter (AMF-PDE) algorithm is proposed to process the output image of the ultraviolet ICCD camera. The outcomes display that AMF-PDE can get the better-submerged sign and preserve details of UV detection picture correctly.

[12] In this paper, the SOM founded procedure is proposed for MRI picture processing. Such pictures are generally corrupted by way of Rician noise generated at some point of the picture formation processing because of the nature of the MRI approach. Rician noise is non-additive, signal based, and rather nonlinear, appreciably exceptional from those commonly discussed in pictures. These features make it very difficult to separate the signal from noise. A SOM set of rules is cautiously carried out to correct MRI IP with the aid of taking the respectable Rician noise function into attention, resulting

$$MX = Median (WX) = Xi(n+1)/2; n \text{ is odd}$$

in a unique method for denosing and segmentation.

[13] In this paper, we present an algorithm to do away with SPN from grayscale pictures. It is a more desirable

$$AMF = [X_{n2} \quad i(2) + Xi(n)+1 (2)] ; n \text{ is even}$$

an algorithm which to start with calculates median without thinking about noisy pixels within the processing window. If the noise-free median fee is not to be had within the maximum processing window, the closing processed pixel fee is used because of the alternative. Moreover, in severe conditions along with noise corrupted pure black and white photos, a threshold value is used to determine the pixel value. Experimental outcomes show that our algorithm can perform higher than the other nonlinear filters, suppressing noise level extra than 90% while retaining visible great and vital details of the picture.

III. TYPES OF NOISES

The noise is distinguished through its pattern and using its probabilistic characteristics. There is an ample diversity of kinds of noise. Whilst we concentrate only on the most significant types, namely; Gaussian noise, salt, and pepper noise, poison noise, impulse noise, speckle noise [4].

(i)Gaussian Noise: Gaussian noise is statistical noise that has its probability density function (PDF) equal to that of the normal distribution, which is as well acknowledged as the Gaussian distribution. In other words, the values that the noise can take on are Gaussian-distributed. A special case is white Gaussian noise, in which the values at any pair of times are equally distributed and statistically independent (un co-related). In applications, Gaussian noise is most frequently used as additive white noise to acquiesce additive white Gaussian noise.

(ii) Salt and Pepper Noise: Salt and pepper noise is a kind of noise normally observed on images. It signifies itself as randomly arising white and black pixels. An efficient noise elimination technique for this kind of noise involves the usage of a median filter, morphological filter, or a contra harmonic mean filter. Salt and pepper noise sneaks into images in circumstances where fast transients, such as faulty switching occur.

(iii) Poisson Noise: Poisson noise is induced through the nonlinear response of the image detectors and recorders. This kind of noise is image data reliant. This term occurs since detection and recording processes involve arbitrary electron emission having a Poisson distribution with a mean response value. Since the mean and variance of a Poisson distribution are identical, the image dependent term has a standard deviation if it is assumed that the noise has a unity variance.

(iv) Impulse Noise: Impulse noise is a class of (acoustic) noise that comprises unwanted, approximately instantaneous (impulse-like) sharp sounds (like, clicks and pops). Noises of this kind are generally caused by electromagnetic interference, scratches on the recording disks, and ill synchronization in digital recording and communication. Impulse noise corruption is most familiar with digital images. Impulse noise is always independent and uncorrelated to the image pixels and is randomly distributed over the image. Hence unlike Gaussian noise, for an impulse noise corrupted image all the image pixels are not noisy, several image pixels will be noisy and the rest of the pixels will be noise-free. There are different types of impulse noise namely salt and pepper type of noise and random valued impulse noise.

IV. DENOISING METHODS

Removing noise from images is the primary objective of Image Processing. Image denoising methods can be classified into the following categorizations.

(i) Spatial Domain Filters: These are the most commonly used methods for removing noise from digital images. Spatial Domain filtering can be categorized into Linear and nonlinear Filters.

(ii) Linear Filters: These filters blur sharp edges and destroy other image details. Linear filter performance will be poor in the case of signal-dependent noise. Some Linear filters are Mean Filters, Wiener Filters, Gradient Filters, Laplacian Filters Low pass Filters, and High Pass Filters

(iii) Mean Filters: A mean filter is a sliding window filter that replaces the focal incentive in the window with the normal mean of all pixel esteems in the portion or window. This window is normally square yet can be of any shape[5].

(iv) Wiener Filter: This relies upon measurable methodology. It filters through the noise that had debased a signal [6].

Low Pass Filter: Also called as Gaussian Filter. They blur the images and eliminate noise and details. Not effective in eliminating salt and pepper noise [7].

Non-Linear Filters: Non-Linear filters better than linear filters. Some of the nonlinear filters are Median Filter, Min Filter, Max Filter, Ridge Filter, etc.

(v) Median Filters: Median filter is a nonlinear filter and useful in smoothing images. It is utilized for intensity force variety among one and another pixel. Unlike Mean filters, there is no necessity for replacing the pixel of an image with an average of neighbor pixels, instead, we will replace it with the median value.

In this method, first sort all the pixel values in ascending order and replace the middle pixel value [8].

(vi) Min Filters: Min filters alias 0th percentile filter replaces a pixel value with the minimum intensity level of its neighboring pixel. It also finds the darkest points in the image. These are also used to remove salt noise from the images that contain salt & pepper noise [9].

(vii) Max Filter: Max Filters, also known as 100th percentile Filter replaces pixel value with intensity level (maximum) of the neighborhood of the concerned pixel. It locates the brightest point in an image [10].

(viii) Wavelet-based Thresholding: A signal estimation technique and exploits the capabilities of wavelet transforms to the signal denoising [6]. Various Thresholding techniques like Hard & Soft Thresholding fulfill the purpose of removing noise from images. Hard thresholding based on honor and rule instinctively and introduces art crafts in the recovered image. Soft Thresholding reduces the coefficients above the threshold in absolute value.

(ix) **Other Filters:** Besides traditional filters, various Fuzzy filters can be used for noise removal from images [11].

Fuzzy Classical Filters: These filters use Fuzzy logic and can be classified in to (i) Fuzzy Median Filter and (ii) Fuzzy Impulse noise Detection & removal method. These filters are entirely dependent on fuzzy logic and are not related to classical filters. Some of them are discussed below:

(i) **Gaussian Noise Reduction Filter:** This Filter is designed to remove Gaussian Noise and finds an average of the pixel using neighborhood pixels. These also take care of details such as edges. Two features are required for the acquirement of the above conditions.

(ii) **Histogram Adaptive Filters:** These filters remove high impulse noise along with preserving edge details.

V. CONCLUSION

Image denoising technique has been an everlasting research topic for researchers and one motive for this is a deficiency of a solitary approach, which is competent to accomplish denoising for a broad category of images. However, conventional linear noise reduction approaches such as Wiener filtering has been in existence for a long instant because of their simplicity and are capable to attain substantial noise elimination when the variance of the noise is low, they cause blurring and smoothening of the sharp edges of the image. Therefore, presently there has been a considerable quantity of research on non-linear noise suppression methods and well-known amongst them are the wavelet-based denoising approaches. Wavelet transform is most suitable for performance due to its properties such as sparsity, multiresolution, and multi-scale character, which wavelet is employed depends on the nature of the application. DWT has a limitation of Shift invariance while daubechies wavelet transform is competent to eliminate noise and a novel approach fast wavelet transform signifies with less memory obligation and less complication. Hence, knowledge of noise models and image denoising approaches is a very significant part of image processing. To cater to the need of this fundamental information in this paper a comprehensive review of noise models and image denoising approaches available has been carried out and presented. This presented work will provide basic material for researchers especially the new entrants in the area of image processing.

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