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Comparison and Analysis of Different Denoising Techniques in Image Processing

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ABSTRACT

Image restoration one part is the Denoising which plays important tasks in image processing. Despite the significant research conducted on this topic, the development of efficient denoising methods is still a compelling challenge. Image denoising is an essential requirement of image processing. The images contain strongly oriented harmonics and edge discontinuities. Wavelets, which are localized and multiscaled, do better denoising in single dimension using multiple local thresholding technique. Filter based denoising and reconstruction exhibit higher quality recovery of edges and curvilinear features. This thresholding scheme denoises images embedded in Speckle noise. The experiment shows denoising using Filters such as Wiener, Median, Wavelet Transform to outperforms in terms of MSE (mean square Error) but also in better visual appearance of the resulting images. In this thesis, we will study and investigate the application of using best filters to remove noise. In this, Gaussian, Poisson, Salt & pepper, Speckle is used for restoration.

Keywords : Gaussian, Poisson, Salt & Pepper, Speckle noise, Denoising, filters, MSE.

I. INTRODUCTION

The face is our primary focus of attention in social life Image restoration is an art to improve the quality of image via estimating the amount of noises and blur involved in the image. With the passage of time, image gets degraded due to different environmental conditions, so it is required to restore the original image using different image processing algorithms. There is a wide spread application of image restoration in today's world. Application area varies from restoration of old images in museum and radar based image acquisition and restoration.

Image denoising is a necessary step in image processing applications. In brief, all these algorithms first perform the wavelet transform of the image to denoised, apply some filter to the wavelet coefficients, and finally take the inverse wavelet transform to restore the denoised image. Most popular wavelet-filtering algorithms are based on thresholding.

Wavelet analysis has been demonstrated to be one of the powerful methods for performing image noise reduction. The procedure for noise reduction is applied on the wavelet coefficients obtained after applying the wavelet transform to the image at different scales. The motivation for using the wavelet transform is that it is good for energy compaction since the small and large coefficients are more likely due to noise and important image features, respectively. The small coefficients can be threshold without affecting the significant features of the image. In its most basic form, each coefficient is threshold by comparing against a value, called threshold. If the coefficient is smaller than the threshold, it is set to zero; otherwise it is kept either as it is or modified. The inverse wavelet transform on the resultant image leads to reconstruction of the image with essential characteristics.

Image denoising is a fundamental process in image processing, pattern recognition, and computer vision fields. The main goal of image denoising is to enhance or restore a noisy image and help the other system (or human) to understand it better.

Image Denoising Technique

There are different Image denoising techniques developed so far each having its own advantages and limitation. One should choose the technique according to the type and amount of noise present in the image. One should also consider the other factors like performance in denoising the image, computational time, and computational cost.

A. Different Type of Noise

The noise is characterized by its pattern and probabilistic characteristics. There is a wide variety of noise types. Some of them are: Gaussian noise, salt and pepper noise, poison noise, speckle noise.

Gaussian Noise- Gaussian noise is statistical noise that has its probability density function equal to that of the normal distribution, which is also known 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 identically distributed and statistically independent (and hence uncorrelated). In applications, Gaussian noise is most commonly used as additive white noise to yield additive white Gaussian noise .

Salt and Pepper Noise- Salt and pepper noise is a form of noise typically seen on images. It represents itself as randomly occurring white and black pixels. An effective noise reduction method for this type of noise involves the usage of a median filter, morphological filter or a contra harmonic mean filter. Salt and pepper noise creeps into images in situations where quick transients, such as faulty switching take place .

Poission Noise- Poison noise is induced by the nonlinear response of the image detectors and recorders. This type of noise is image data dependent. This term arises because detection and recording processes involve random electron emission having a Poison distribution with a mean response value. Since the mean and variance of a Poison distribution are equal, the image dependent term has a standard deviation if it is assumed that the noise has a unity variance .

Speckle Noise- Speckle is a complex phenomenon, which degrades image quality with a backscattered wave appearance which originates from many microscopic diffused reflections that pass through internal organs and makes it more difficult for the observer to discriminate fine detail of the images in diagnostic examinations. This type of noise occurs in almost all coherent systems such as SAR images and Ultrasound images. The source of this noise is random interference between the coherent returns. The speckle noise follows a gamma distribution. Thus, de noising or reducing the noise from a noisy image has become the predominant step in medical image processing. For the quality and edge preservation of images we have taken different de noising techniques into consideration [6].

B. Different Type of Filters

The main function of filters is to suppress either the high frequencies in the image, that is smoothing the image, or the low frequencies, that is enhancing or detecting edges in the image.

a) Mean Filter- Mean filtering is a simple, intuitive and easy to implement method of smoothing images, *i.e.* reducing the amount of intensity variation between one pixel and the next. It is often used to reduce noise in images. The idea of mean filtering is simply to replace each pixel value in an image with the mean (`average') value of its neighbors, including itself. This has the effect of eliminating pixel values which are unrepresentative of their surroundings.

b) Wiener Filter- The wiener filtering method requires the information about the spectra of the noise and the original signal and it works well only if the underlying signal is smooth. Wiener method implements spatial smoothing and its model complexity control correspond to choosing the window size [9]. Wiener filtering is able to achieve significant noise removal when the variance of noise is low, they cause blurring and smoothening of the sharp edges of the image [10].

c) Median Filter- Median filtering is a common step in image processing. Median filter is a well-used nonlinear filter that replaces the original gray level of a pixel by the median of the gray values of pixels in a specific neighbourhood. The median filter is also called the order specific filter because it is based on statistics derived from ordering the elements of a set rather than taking the means. This filter is popular for reducing noise without blurring edges of the image [6]. It is

particularly useful to reduce salt and pepper noise and speckle noise. It is very useful in case where edge blurring is undesirable because of its edge preserving nature.

d) Gaussian Filter- Gaussian filters are designed to give no overshoot to a step function input while minimizing the rise and fall time. This behaviour of Gaussian filter causes minimum group delay. Mathematically, a Gaussian filter modifies the input signal by convolving with a Gaussian function. The Gaussian filter is usually used as a smoother. The output of the Gaussian filter at the moment is the mean of the input values [12].

II. LITERATURE SURVEY

In 2014 Arpita and et al and others in their research paper titled "impact of wavelet transform and median filtering on removal of salt and pepper noise in digital images" explained Image acquisition is a common task in every image processing operation. Noise is entered during image acquisition from its source and once entered it degrades the image and is difficult to remove. In order to achieve the noise cancellation in an image, non-linear filter works better than linear. This paper presents the joint scheme of Wavelet Transform using iterative noise density and Median Filtering to remove Salt and Pepper Noise in Digital Images. The first part of the paper derives the wavelet coefficients with slight increase in noise density and in second part these coefficients are further modified by median filter. The algorithm shows the remarkable improvement over Gaussian noise model and removes most of the noisy part from the image and maintains the visual quality. The level of wavelet decomposition is restricted to three. The renowned indexes Peak Signal to Noise Ratio (PSNR) and Root Mean Square Error (RMSE) demonstrate marked improvement of image denoising over Gaussian method [1].

In 2014 Sezal Khera and others in their research paper titled "survey on medical ımage de noising using various filters and wavelet transform" explained that There is a problem of high level components of noises in the Medical Images. The different medical images are Magnetic Resonance Imaging (MRI), X-ray, Computed Tomography and Ultrasound. There are many noise reduction techniques that have been developed for removing noise. The idea behind these techniques is to get better results in terms of quality and in removal of different noises. This paper gives the review of various de noising techniques [2].

In 2014 Seema and others in their research paper titled "wavelet based technıque for removal of multıple noıses sımultaneously" presented that Denoising is important pre-processing tasks for various image processing. Image noise is the random variation of brightness and color information in images produced by the scanner and digital camera. This paper presents a novel approach for simultaneously removing the speckle and Salt-n-pepper noise from a single image by using the median filter. This paper proposes an adaptive, data-driven threshold for image denoising via wavelet soft thresholding. The threshold is derived in a Bayesian framework and also using the MAD (mean absolute difference) value of fast multidirectional filter bank which improves the radial frequency resolution of the image by addition decomposition in the high frequency band. Denoising performance of median filter will be compared with discrete wavelet transform and wiener filter. The performance of median filter using parameter metrics PSNR (Peak Signal to Noise Ratio) and coefficient of correlation (Coc) is also analyzed [4].

In 2013 Himanshu and others in their research paper titled "ımage denoising by hybrid average gaussian filter for different noises" presented the study of four types of noises such as Gaussian, Salt and Pepper, Poisson, and Speckle noise. Image denoising is not only significant on the contrary problem of image processing which is helpful in the fields of remotely sensed scene interpretation, Biomedical imaging techniques, Gathering image's lost information, image retrieval, mining of image etc, and an essential preprocessing technique to preserve the clarity of the naturally corrupted image which may be affected by the various types of noises. This paper reviews on the existing various filters having various variance of noises. Further, it analyses, examines and compares various filters with the proposed filter. The experimental results shown to be precised in terms of SNR and variance in noise. The results consider the quantitative measures of comparing the denoised images as output of various filters and the hybrid filter with the help of Root Mean Square Errors (RMSE) and Peak-Signal to Noise Ratio (PSNR)[3].

In 2010 Pawan and others in their research paper titled "ımage de-noising by various filters for different noise" presented that Image processing is basically the use of computer algorithms to perform image processing on digital images. Digital image processing is a part of digital signal processing. Digital image processing has many significant advantages over analog image processing. Image processing allows a much wider range of algorithms to be applied to the input data and can avoid problems such as the build-up of noise and signal distortion during processing of images. Wavelet transforms have become a very powerful tool for de-noising an image. One of the most popular methods is wiener filter. In this work four types of noise (Gaussian noise , Salt & Pepper noise, Speckle noise and Poisson noise) is used and image de-noising performed for different noise by Mean filter, Median filter and Wiener filter . Further results have been compared for all noises [5].

III. IMPLEMENTATION AND RESULT

A graphical user interface has been developed in matlab having the following features :-

- Types of noise
  - i) salt and pepper
  - ii) Gaussian
  - iii) speckle
- Types of filters
  - i) Average filter
  - ii) median filter
  - iii) Gaussian filter
  - iv) wiener filter
- Types of image color functions
  - i) Color images
  - ii) Grayscale images
  - iii) Inverted color images
- Comparison modes
  - i) 2d comparison
  - ii) 3d comparison
  - iii) comparison by means of MSE (mean square error

GUI model prepared in Matlab:

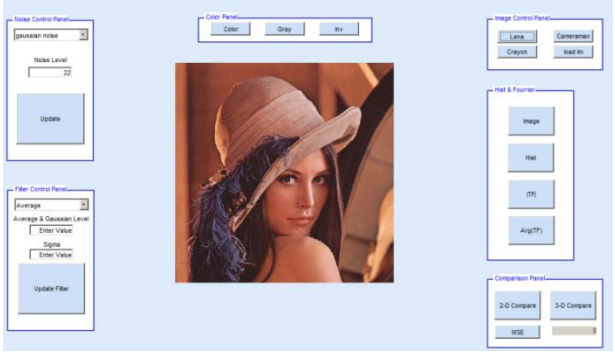

Figure 1. GUI prepared in Matlab

Result from different parameter sets-

1) Noise type :- Salt & pepper

- Noise level :- 5 %
- Average level :- 3
- Gaussian level :- 0.25

a) Use Average filter, MSE= 18.05

(a) (b)

Figure 2. (a)Leena image without filter, (b) image with filter

b) Use Gaussian filter, MSE = 6.21

(c) (d)

Figure 3. (c)Leena image without filter, (b) image with filter

c) Use Median filter, MSE = 3.33

(e) (f)

Figure 4. (e)Leena image without filter, (f) image with filter

d) Use Wiener filter, MSE = 13.49


(g) (h)

Figure 5. (g)Leena image without filter, (h) image with filter

2) Noise type :- Gaussian noise
   - Noise level :- 5%
   - Average level :- 3
   - Gaussian level :- 0.25

a) Use Average filter, MSE = 4.19


(i) (j)

Figure 6. (i)Leena image without filter, (j) image with filter

b) Use Gaussian filter, MSE = 25.5


(k) (l)

Figure 7. (k)Leena image without filter, (l) image with filter

c) Use Median filter, MSE :- 1.2


(m) (n)

Figure 8. (m)Leena image without filter, (n) image with filter

d) Use wiener filter, MSE :- 0.77


(o) (p)

Figure 9. (o)Leena image without filter, (p) image with filter

3) Noise type :- Speckle noise
   - Noise level :- 5%
   - Average level :- 3
   - Gaussian level :- 0.25

a) Use Average filter, MSE = 20.7


(q) (r)

Figure 10. (q)Leena image without filter, (r) image with filter

b) Use Gaussian filter, MSE = 90.9


(s) (t)

Figure 11. (s)Leena image without filter, (t) image with filter

c) Use Median filter, MSE = 32.2


(u) (v)

Figure 12. (u)Leena image without filter, (v) image with filter

d) Use Wiener filter, MSE = 22.9


(w) (x)

Figure 13. (w)Leena image without filter, (x) image with filter

IV. CONCLUSION

In this paper, various noise models and filtering techniques like linear, nonlinear filtering and adaptive filtering have been discussed.

For salt and pepper noise median filter provides us the best mean square error in the image . But it must be noted that as the noise level in the image increases then in that case gaussian filter becomes utterly useless with our parameters. Until the value of sigma is increased, the gaussian filter fails to give any conclusive results.

For speckle noise average filter provides us the best mean square error in the image. The gaussian filter on the other hand proves to be extremely successful as soon as the value of sigma is increased. Thus it can be said that for higher values of sigma Gaussian filter must be used for this type of noise else average filter must be used.

For gaussian noise there is no match to the results given by wiener filter in all the cases. In fact the MSE for wiener filter is so very less that it can be neglected also. It must however be interesting to note that for gaussian noise the MSE for all the other filters are also quite low as compared to their respective MSE's for other noises.

V. FUTURE SCOPE

This comparative study can be further extended by including more noise types like Exponential noise, anisotropic noise, Film grain etc and/or by using multiple types of noise in different types of images. One can include more spatial filters using various means filters like Arithmetic mean filter, Geometric mean filter, Harmonic mean filter, Contra harmonic mean filter and order statistics filters like Midpoint filter, Alpha trimmed filter and Additive filters like Adaptive local noise reduction filter for comparison. One can also use hybrid filtering approach which involves two or more filters. Some other parameters like Entropy, Structure Similarity Index and Image Quality can also be considered for measuring the performance of different filters.

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