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Image De-noising Using ROF Technique

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Abstract: ***De-noising is the process of removing noise from an image. Additive white Gaussian noise (AWGN) case is the most studied case for de-noising in image processing. A technique implementing with the help of total variation de-noising as the proposed method is described. In this paper, we define the task of image de-noising as follows. We are providing a gray-scale type image for de-noising purpose that has been already degraded with different type of noises that has been further discussed in this paper. The variance of the noise is assumed to be known. The main goal of this technique is to retrieve our original one. Total variation regularization or we can say total variation de-noising is a technique that was originally developed for AWGN image de-noising by Rudin, Osher, and Fatemi[1]. The Total variation regularization/de-noising technique has since been applied to the different kind of other imaging problems. We focus here on the ROF de-noising technique.***

Keywords: Total Variation De-Noising, Additive White Gaussian Noise, Speckle Noise, Impulse(Random) Noise, Salt & Pepper Noise, Fuzzy Filters, Peak to Signal Ratio, Mean Square Error

1. Introduction

Image de-noising refers to the retaining the properties of an image that has been degraded by different kind of noise. The presence of noise in images is unavoidable. It may be applied at the time of formation of image, recording or transmitting period. Further processing of the image often requires that the noise must be removed or at least reduced. Even a small amount of noise is harmful when high accuracy is required. The noise can be of different types. The most popular ones are additive white Gaussian noise (AWGN), speckle noise, impulse noise, Poisson noise etc. Mathematically the degradation process can be denoted as A= B&C. Here B is the clean image, A the noisy image and C is the noise. ′&′ is a mathematical operation which can be addition or may be multiplication depending upon that what type of noise is introduced. An image de-noising algorithm tries to retrieve the best estimation of F from G. Generally optimization criteria will be MSE based i.e Mean Squared Error.

Different type of problems are there which are introduced with enhancement of an image, that makes this a challenging task. One of them is reducing/removing of noise and edge enhancement or certain several other salient structures in the image[2]. Many different types of noise like salt and pepper noise, additive white Gaussian noise (AWGN), multiplicative noise etc. are generally occurs into images because of different type of factors some of them are environmental conditions, quality of sensing elements, sensor temperatures, light levels etc. So, several noise removal algorithms are used for different noise types. As it is very difficult to say which type of noise is going to affect our image, so in this paper, we are going to develop an algorithm which helps us to combat against salt and pepper noise, Gaussian noise, impulse noise, speckle noise and poison noise. Generally non-linear filters like median filter, Wiener filter etc. have been widely used in image de-noising because of their better performance in terms of noise attenuation and details preservation. But they have several limitations as well. Standard median (SM) filter causes blurring of image details, hence affecting the image fidelity badly and fails at high levels of corruption. Wiener filter executes an optimal trade-off between inverse filtering and noise smoothing. It removes the additive noise, minimizes the MSE and inverts the blurring simultaneously. But MSE is not a universal criterion and it may lead to undesirable output. As the amount of noise added in the image increases, both Wiener and median filters will under-perform. The work described in this paper was created to attempt to find a way to perform de-noising in* images, which are degraded by different types of noise which are described. So, in this paper we have introduced an algorithm which will very useful when noise will be introduce into the images.

2. Image De-noising Techniques

Over the last decades, a variety of methods have been proposed for image de-noising. This includes spatial filtering methods, transform based methods, variational methods and techniques based on the solution of partial differential equations. There are various factors which need to be considered in selecting a noise reduction algorithm. They are the available computer power and time, whether sacrificing some real detail is acceptable if it allows more noise to be removed and the characteristics of the noise. Here in our technique we are using total variation with minimization to reduce noise from the images. Total variation[3] (TV) regularization is a technique that was originally developed for AWGN image de-noising by Rudin, Osher, and Fatemi. Noe we have proposed a technique that can be applied for salt and pepper noise, Gaussian noise, impulse noise, speckle noise and poison noise.

3. Proposed De-noising Technique

A gray level image is used in this paper. In this technique we are using 256X256 ‘*cameraman.tif*’ image files that are easily available in Matlab environment. This de-noising method is based on total-variation technique, originally proposed by Rudin, Osher and Fatemi. Total variation de-noising is also know as total variation regularization which is generally used in image processing for image de-noising. It is based on the principle that signal with excessive and possibly spurious details have high total variation, i.e. integral of the absolute gradient of the signal is high. According to this, reducing the total variation of the signal subject to it being a close match to the original signal that removes the unwanted detail while preserving important details such as edges.

In this particular case fixed point iteration[4] is utilized. For the included image, a fairly good result is obtained by using a theta value around 12-16. PSNR and MSE are also calculated for further analysis.

A. Peak to Signal Ratio (PSNR)

For synthetic speckle images and images corrupted with AWGN, the peak signal-to-noise ratio (PSNR)[5] can be used to evaluate the performance. It is defined as

$$PSNR = 10\log_{10}(R^2/MSE) \quad (1)$$

where R is the maximum fluctuation in the de-noised image and MSE is representing the Mean Square Error between the de-noised image and the original reference image. For an 8 bit image the value of R is 255. Here we are using an 8 bit image so R will be 255 here and it can be rewritten as-

$$PSNR = 10\log_{10}(255^2/MSE) \quad (2)$$

And MSE is given as follows

$$MSE = \sum_{i=0}^{m}\sum_{j=0}^{m}(I-k)^2\, pixel \quad (3)$$

Where
I is input Image i.e. noisy image
k is output image after applying proposed algorithm.
m is the number of iterations

The technique could be interpreted as a first step of moving each level set of the image normal to itself with velocity equal to the curvature of the level set divided by the magnitude of the gradient of the image, and a second step which projects the image back onto the constraint set. This technique is based on the Total Variation De-noising or we can say Regularization where Regularization parameter is to be taken between 12 to 16.

B. Regularization Parameter

The Regularization parameter[6] (theta) has an important role in this technique. As theta is small smoothing will be less and as theta will increase smoothing will increase. So here we have to choose regularization parameter value very carefully for this purpose that is very helpful to remove noise amount. Here in this technique we are using fixed point iteration method[7].In this fixed-point iteration method, it automatically selects a suitable window and optimizes a scalar parameter which is based on a defined noise level.

C. Flow Chart for Proposed Work

The flow chart for the proposed work is given below. As we can see from the first block we have started using Matlab software, after starting with Matlab first task is to load image file in Matlab and after that we'll start de-noising. We'll apply different types of noise on image and when image is noisy then we will apply proposed algorithm that is ROF based, and we have successfully reduce noise amount from the noisy image. After that we'll calculate MSE and PSNR for the resultant images and finally results are plotted.

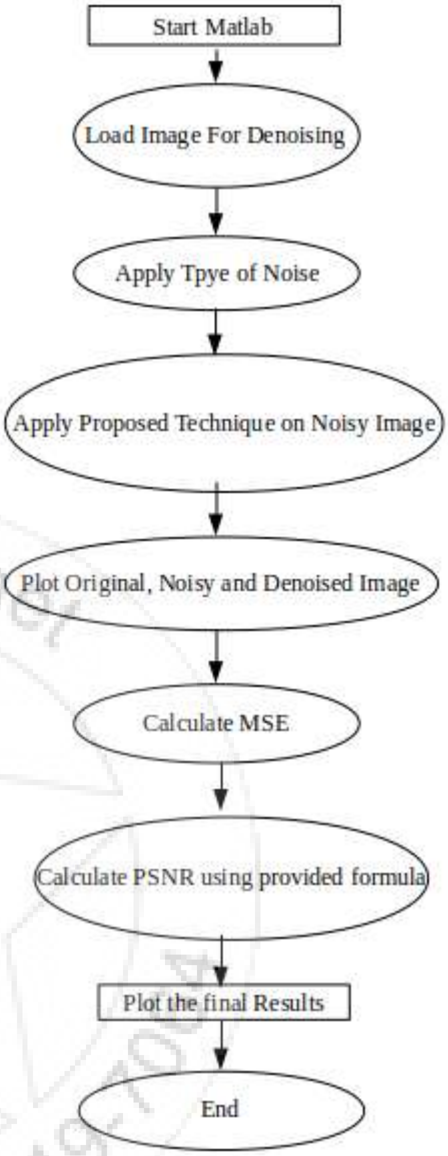

Figure 1: Flow Chart for Proposed Technique

4. Results and Discussion

We have successfully applied the proposed algorithm for image de-noising. Here in our paper we used gray scale cameraman images for de-noising. The variance for noise is we have provided for different type of noise. We have successfully achieved the better results and that results also compared with fuzzy de-noising techniques.

Table 1: Comparison of PSNR values for different type of noise

PSNR Values after applying Proposed Technique					
Sr. No.	*1*	*2*	*3*	*4*	*5*
% of Noise & Type	5%	10%	20%	30%	40%
Gaussian	68.9162	67.3126	66.141	65.28	64.6
Poisson	69.7829				
Impulse	69.48	69.1	68.483	67.8069	67.1776
Speckle	69.48	69.31	68.85	68.31	67.61
Salt&Paper	69.292	68.6946	67.711	66.58	65.22

Here we can see that PSNR values after applying proposed technique are comparatively high that are getting after applying fuzzy technique.[3] i.e around 25 to 35 for different type of noise.

Figure 2: Original Image

This is the original gray image having dimension of 256X256 that is used to perform experiment. We use Matlab 2015a version software to perform all the experiments. This image is taken from the Matlab library where it is easily available as Cameraman.tif.

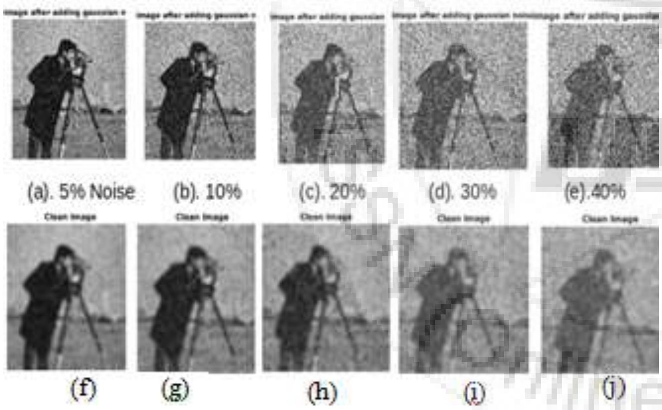

Figure 3: (a) Corrupted image by 5% Gaussian noise, (b) Corrupted image by 10 % Gaussian noise (c) Corrupted image by 20 % Gaussian noise (d) Corrupted image by 30% Gaussian noise (e) Corrupted image by 40% Gaussian noise (f), (g), (h), (I) and (j) respectively results after applying proposed technique on Noisy images

Figure 4: (a) After applying Poisson noise (b) Result after applying proposed technique on noisy image

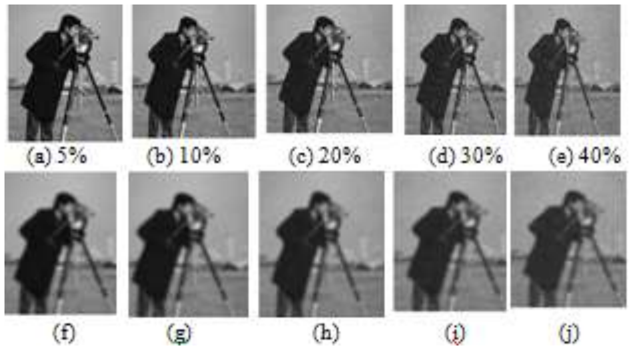

Figure 5: (a) Corrupted image by 5% Impulse noise, (b) Corrupted image by 10 % Impulse noise (c) Corrupted image by 20 % Impulse noise (d) Corrupted image by 30% Impulse noise (e) Corrupted image by 40% Impulse noise (f), (g), (h), (I) and (j) respectively results after applying proposed technique on Noisy images

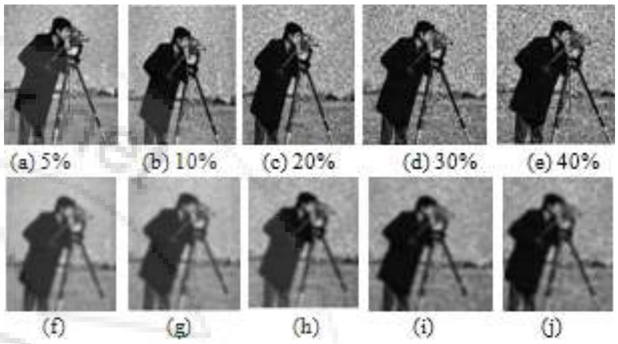

Figure 6: (a) Corrupted image by 5% Speckle noise, (b) Corrupted image by 10 % Speckle noise (c) Corrupted image by 20 % Speckle noise (d) Corrupted image by 30% Speckle noise (e) Corrupted image by 40% Speckle noise (f), (g), (h), (I) and (j) respectively results after applying proposed technique on Noisy images

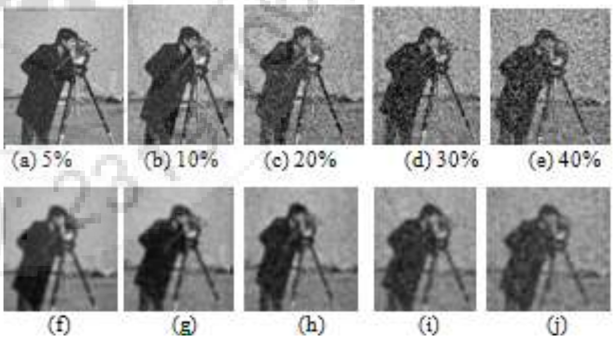

Figure 7: (a) Corrupted image by 5% Gaussian noise, (b) Corrupted image by 10 % Gaussian noise (c) Corrupted image by 20 % Gaussian noise (d) Corrupted image by 30% Gaussian noise (e) Corrupted image by 40% Gaussian noise (f), (g), (h), (I) and (j) respectively results after applying proposed technique on Noisy images

We have successfully perform the experiments on different type of noises i.e. Gaussian noise, Poisson noise, Speckle noise, Impulse(Random) noise and Salt&Pepper noise and successfully achieved the better results than some other technique like fuzzy[3] in the terms of PSNR of resultant images which are given in Table.1. These results show that our proposed technique is very effective in image de-noising than other technique. We have perform qualitative &

quantitative both type of measurements that shows how robust and effective our proposed technique is, in comparison of other de-noising and filtering techniques.

5. Conclusion

In this paper, an efficient and fast de-noising technique has been proposed using Total Variation De-noising based i.e ROF. This ROF technique is a powerful method for de-noising in image processing. The effectiveness of the proposed technique has been tested using both gray scale and can be further on color images with different noise density level for future work. This technique can easily retain the small and sharp details in the test image. This technique confirms that it is robust and more effective as compared to other conventional and advanced techniques in terms of de-noising and exact detail restoration. This method will be very useful for segmentation, registration, identification and sharpening of objects in a complex scene. Our next target is to improve the filtering method capable of removing different type of noise from the image.

Proposed technique in successive iterations builds constructive approximations for component of image signal. Results from this technique are presented here and also compared with different achieved traditional techniques for noise removal. Fuzzy filtration is considered here for comparison. Analysis from generated results conclude that choosing appropriately selected iteration numbers presented algorithm remarkably improves peak signal to noise ratio (PSNR).

Proposed method can be especially useful for degraded images that present different details about this. However, this method can be also useful in different kind of image processing applications and also for analysis purpose as it's a part of image improvement process.

6. Future Work

We have successfully developed the proposed technique with the help of total variation de-noising. The proposed de-noising technique can be very useful for further research in this field. This research can be used for de-noising the other type of images i.e. Colored, Indexed and Binary images. It will give better results over already developed de-noising techniques . Also these techniques can be used for training of various Artificial Intelligence techniques like fuzzy logic or neural network that can be used to get best results without performing calculations for different type of combination.

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