COMPARITIVE STUDY OF IMAGE DENOISING ALGORITHMS IN MEDICAL AND SATELLITE IMAGES

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Abstract

Image Denoising is one of the major uphill tasks existing in the field of research and the finding of an optimum algorithm still remains a needle in the haystack. This paper is an attempt to present an analysis on various interactive algorithms for Image Denoising for denoising medical and satellite images. The images denoised via the algorithms are compared using two image quality metrics, i.e. Mean Square Error (MSE) and Peak Signal to Noise Ratio (PSNR).

KEYWORDS: *Denoising, Peak Signal to Noise Ratio (PSNR), Mean Squared Error (MSE)*

INTRODUCTION

Images from all domains and specifically Medicine or Satellite imagery very often require the best possible denoised versions of an image to be available to be available for further analysis. Earlier, many methods have been applied to get best versions of denoised images. We propose to apply the methods of TV L1, Wavelet, Adaptive Filtering and ROF to perform image denoising and compare the results using the parameters of PSNR and MSE. ROF and TV-L1 Variational denoising models are implemented using Primal-Dual optimization algorithm

Earlier methods in practice attempt to separate the image into the smooth part (true image) and the oscillatory part (noise) by removing the higher frequencies from the lower frequencies. However, not all images are smooth, images can contain fine details and structures which tend to have high frequencies. When the high frequencies components are removed, the high frequency content of the true image also gets removed along with the high frequency noise as the methods already in practice cannot differentiate between the noise and true image. Such operations will result in some loss of details in the denoised image. Moreover, the low frequency noises in the image is not taken care of, they remain a part of the image even after denoising. We propose to apply ROF, TV-L1, Adaptive Filtering and Wavelet algorithm on a noisy image and the result will be compared among several test images. These methods later will be compared using the criterions called PSNR value and MSE value. Visual inspection is probably the best tool to determine the quality of the denoised image. The images are expected to be clear and clean of any artefacts or noise. The MSE comparison between the denoised image and true image will show mathematically how close the resulting denoised image is to the true image. Although, a lower MSE does not guarantee that one image will look better than another image.

The algorithms will be computed using some built-in functions from the MATLAB Image Processing Toolbox. All test images taken constituted the databases of Medical Research history and Satellites.

This work has several applications in variety of scientific domains like Satellite Imaging, Map Determination, Medical Imaging, Optical Character Recognition (OCR), Non-Destructive Testing, etc. The program hence developed will be tested with various pictures for its consistency and its reliability.

1. Noises used in the processing

The original meaning of "noise" is "unwanted signal"; unwanted electrical fluctuations in the signals received by AM Radios caused audible acoustic noise commonly referred as "static". By analogy, unwanted electrical fluctuations thereafter came to be known as "noise". There are several types of noise like Gaussian noise, periodic noise, shot noise etc. The noise we have used in this paper is salt and pepper noised images. Noise is added for comparison purposes only to the original image for calculating the image metrics correctly.

1.1 Salt-and-pepper noise

Fat-tail distributed or "impulsive" noise is sometimes called salt-and-pepper noise or spike noise. An image containing salt-and-pepper noise will have dark pixels in bright regions and vice-versa. This type of noise can be caused by Analog-to-Digital conversion errors or bit errors in transmission. It can be mostly eliminated by using dark frame subtraction, median filtering and interpolating around dark/bright pixels.

2. Parameters used for image Denoising

2.1 Peak Signal to noise ratios

A good quality photograph has about 256 grey level values, where 0 represents black and 255 represents white. Measuring the amount of noise by its standard deviation, σ(n), one can define the signal noise ratio (SNR) as SNR = σ(u), where σ(u) denotes the empirical standard deviation of u, σ(u) = Ã 1 |I| X i∈I (u(i) − u) 2 !1 2 and u = 1 |I| P i∈I u(i) is the average grey level value. The standard deviation of the noise can also be obtained as an empirical measurement or formally computed when the noise model and parameters are known. A good quality image has a standard deviation of about 60.

2.2 Mean Squared Error

In statistics, the Mean Squared Error (MSE) or Mean Squared Deviation (MSD) of an estimator measures the average of the squares of the errors or deviations i.e., the difference between the estimator and what is estimated. MSE is a risk function, corresponding to the expected value of the squared error loss or quadratic loss. The difference usually occurs because of randomness or because the estimator doesn't account for information that could produce a more accurate estimate.

The MSE is a measure of the quality of an estimator—it is always non-negative, and values closer to zero are better.The MSE is the second moment of the error, and thus incorporates both the variance of the estimator and its bias. For an unbiased estimator, the MSE is the variance of the estimator. Like the variance, MSE has the same units of measurement as the square of the quantity being estimated. In an analogy to standard deviation, taking the square root of MSE yields the root-mean-square error or root-mean-square deviation, which has the same units as the quantity being estimated.

3. **Algorithms in use**

3.1 Adaptive Filtering

The Adaptive Filter performs spatial processing to determine which pixels in an image has been affected by impulse noise. The Adaptive Median Filter classifies pixels as noise by comparing each pixel in the image to its surrounding neighbour pixels. The size of the neighbourhood is adjustable, as well as the threshold for the comparison. A pixel that is different from most of its neighbours, as well as not being structurally aligned with those pixels to which it is similar, is labelled as impulse noise. These noise pixels are then replaced by the median value of the pixels in the neighbourhood that have passed the noise labelling test. The purpose of adaptive filtering is to:

1) Remove impulse noise

2) Smoothing of other noise

3) Reduce distortion, like excessive thinning or thickening of object boundaries

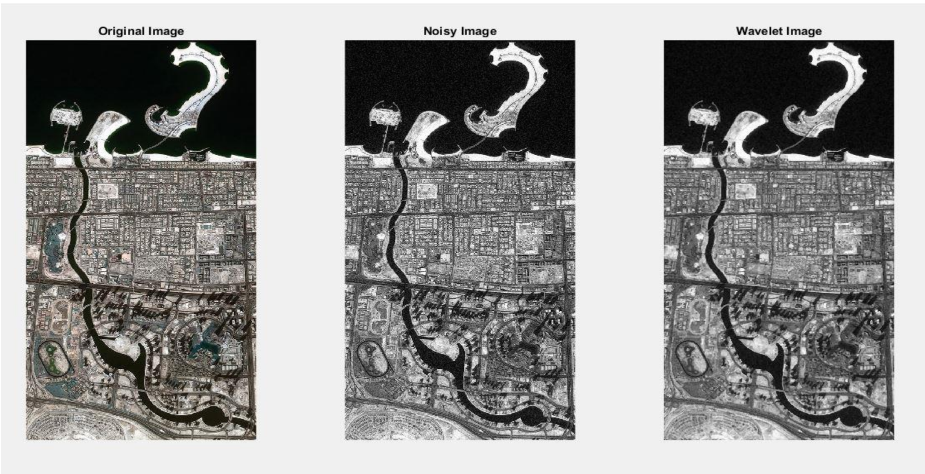

Fig 3.1 Implementation on satellite picture

3.2 Total Variation - L1 and ROF algorithm

In signal processing, total variation denoising, also known as total variation regularization is a process that has applications in noise removal. It is based on the principle that signals with excessive and possibly spurious details have high total variation, that is, the integral of the absolute gradient of the signal is high. According to this principle, reducing the total variation of the signal subject to it being a close match to the original signal, removes unwanted detail whilst preserving important details such as edges. The concept was pioneered by Rudin et al. in 1992 and is today known as the *ROF model*.

This noise removal technique has advantages over simple techniques such as linear smoothing or median filtering which reduce noise but at the same time smooth away edges to a greater or lesser degree. By contrast, total variation denoising is remarkably effective at simultaneously preserving edges whilst smoothing away noise in flat regions, even at low signal-to-noise ratios.

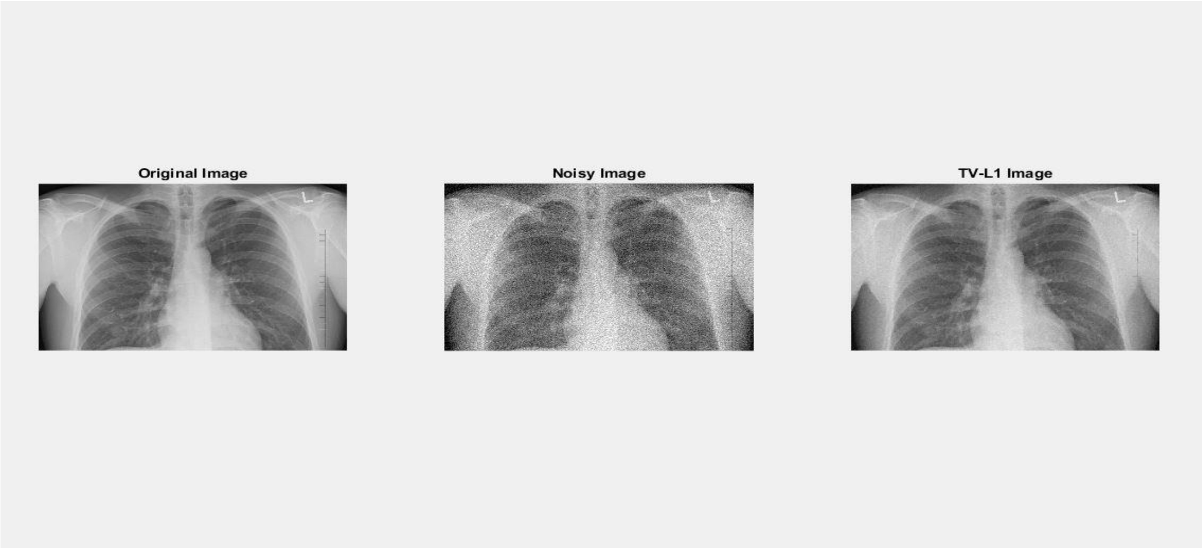

Fig 3.2.1 : Implementation on medical image using TV-L1 algorithm

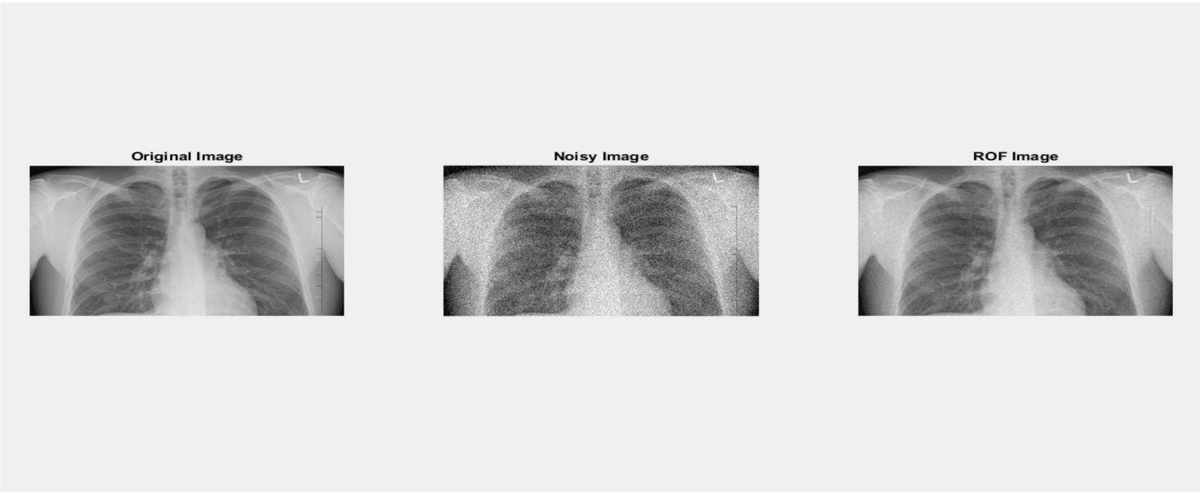

Fig 3.2.2: Implementation on medical image using ROF algorithm

3.3 Wavelet algorithm using hard thresholding.

Wavelet transform is a time-frequency analysis method with fixed window size and varied shape with time. Principle of removing noise by wavelet transform is that the noise mostly belongs to the high frequency information. Therefore, noise information is mostly concentrated in sub blocks with infra-low frequency, infra-high frequency, and high frequency. Sub blocks with high frequency are almost composed of noise information. Therefore, if we set high frequency sub block to zero and suppress low frequency and high frequency sub blocks on certain inhibition, it can achieve a certain effect of the noise removal.

Now, the wavelet transform is often used to remove the white Gaussian noise. Due to the characteristic of multi-resolution analysis of wavelet transform, it can be put in the signal and noise in different frequency domain to recognize them. Although, largely wavelet denoising can be seen as a low pass filter, it is still better than the traditional low pass filter due to the retaining of the image feature after denoising. Thus, wavelet denoising is actually a comprehensive feature extraction and low passes filter function.

There are mainly two methods to process: hard thresholding and soft thresholding. We are working on the hard thresholding technique.
Although the hard threshold is the natural choice and it can preserve the image edge details, the hard threshold function is discontinuity and it would cause ringing and pseudo Gibbs effect when used in the Denoising which are the pitfalls of using this method.

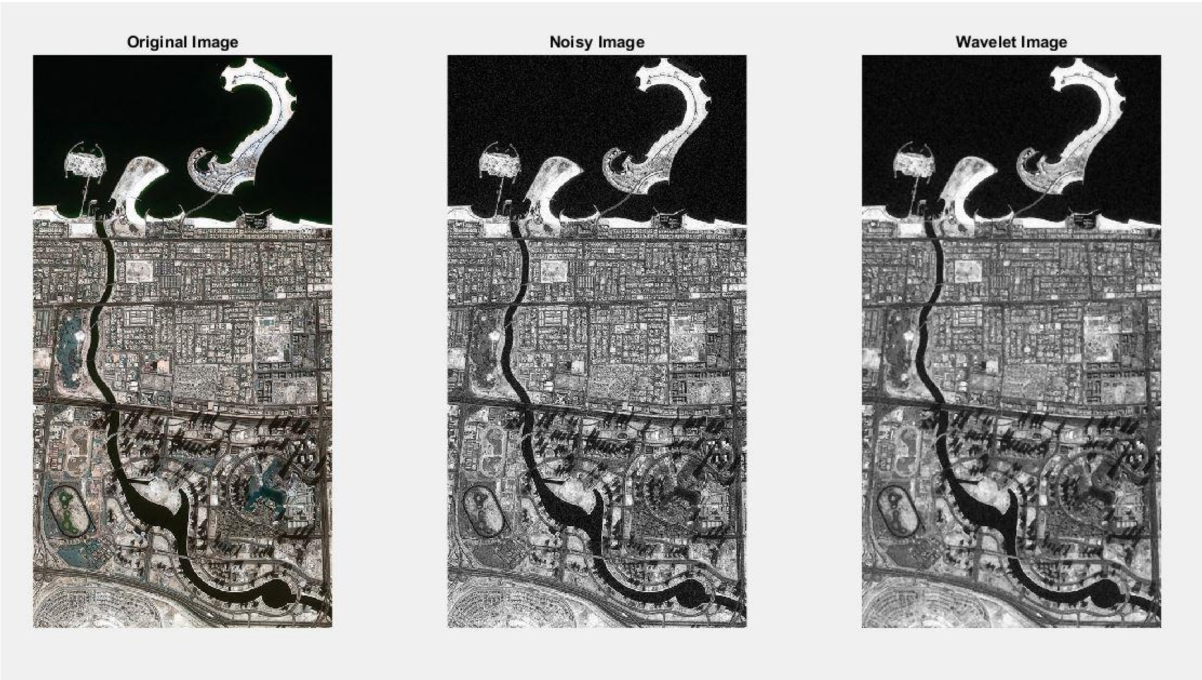

Fig 3.3: Implementation on medical image using wavelet algorithm

4. Result and Interpretation

The algorithms were carried out on two types of images satellite and medical images. The results according to the adopted parameters, PSNR and MSE values for the various images are as follows:-

4.1 Result for medical images

1) TV-L1-
- MSE-0.00403399
- PSNR-23.94264724

2) ROF-
- MSE-0.00408014
- PSNR-23.89325144

3) Adaptive Filtering-

- MSE-0.00417636
- PSNR-23.79201880

4) Wavelet-

- MSE-0.00477237
- PSNR-23.21266320

4.2 Result for satellite images

1) TV-L1-

- MSE-0.00762008
- PSNR-21.18040521

2) ROF-

- MSE-0.01421635
- PSNR-18.47211894

3) Adaptive Filtering-

- MSE-0.00831710
- PSNR-20.80028062

4) Wavelet-

- MSE-0.00996999
- PSNR-20.01305133

As per the comparative study of various algorithms, Adaptive Filtering has been recognized to be the best algorithms among the above four Denoising algorithms for medical and satellite images.

5. Conclusion

In this paper, the removal of Salt and Pepper noise from Medical and Satellite Images has been discussed. As per the work carried out, Adaptive Filtering algorithm is found to be more efficient than the wavelet method, ROF and TV-L1 in Image Denoising particularly for the removal of Salt and Pepper noise. Thus, the obtained results in qualitative and quantitative analysis show that adaptive filtering algorithm outperforms the other methods both visually and in terms of PSNR and MSE values.

6. References

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