Medical image denoising by bilateral filtering & Pure-let for corrupted poisson images

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Abstract

Objective- In this paper, we will demonstrate the two denoising techniques on medical images corrupted by poisson noise. These techniques are analyzed both qualitatively and quantitatively.
Methods & analysis: The work is implemented in Matlab software in image processing toolbox and for Quantitative analysis mean square error(MSE) is used.
Findings: Image denoising by the PURE-LET yields better results.
Conclusion/improvement: PURE-LET techniques is better for denoising medical images corrupted with Poisson noise

Keyword: Image denoising, bilateral filter, PURE-LET, mean square error ,shot noise.

1. Introduction

Noise is unwanted signal which make images visually unpleasant, bad for compression & bad for analysis. There is need for image denoising.

Types of noise are [1] Gaussian noise , Salt and pepper noise , Shot noise , Uniform noise ,Film grain noise , Anisotropic. Images are corrupted with these type of noises during various acquisition procedure. In this paper we will use two image denoising techniques to remove shot or Poisson noise. Poisson noise is dominant noise in the darker parts of image from an image sensor. This noise is called photon shot noise [2]. We will use bilateral filter & PURE-LET on images corrupted by Poisson noise. These denoised images can be used in various image processing tasks like **1.** Image registration [3,4,5] **2.** image fusion [6]. Before use these denoised images for purpose like image registration & image fusion, these can be sharpened by using frequency domain filters [7,8,9] to enhance the diagnostic details of medical images.

2. Literature review

A lot of techniques on image denoising have been reported in the last decade. In [10] proposed an effective denoising techniques use for astronomical images corrupted by shot noise. In [11] proposed an image denoising techniques based on gradient histogram estimation and preservation for texture enhanced. In [12] proposed a denoising technique based on edge preserving using epsilon median filtering in tetrolet domain. In [13] proposed image denoising based on local clustering frame work.

3. Bilateral filter

Bilateral filter is used for image denoising. It can be used for image smoothing. It has properties like it is non linear & also edge preserving. It also has certain demerits induce image artifacts. The two limitations imposed by bilateral filter are - **1.** Stair case effect **2.** Gradient reversal. The bilateral filter is defines as [14]

$$I^{filtered}(x) = 1/W_P \sum_{xi \in \Omega} I(xi) fr(||I(xi) - I(x)||) g_s(||xi - x||)$$

where the normalization term

$$W_P = \sum_{xi \in \Omega} fr(||I(xi) - I(x)||) g_s(||xi - x||)$$

ensures that the filter preserves image energy and

- $I^{FILTERED}$ is the filtered image;
- I is the original input image to be filtered;
- X are the coordinates of the current pixel to be filtered;
- Ω is the window centered in x;
- f_r is the range kernel for smoothing differences in intensities. This function can be a Gaussian function;
- g_s is the spatial kernel for smoothing differences in coordinates. This function can be a Gaussian function;

4. Pure-Let

PURE-LET is poisson unbiased risk estimate linear expansion of thresholds. PURE is defined in unnormalized HAAR wavelet. PURE-LET is elaborated in [15] and [16]. Three PURE-LET are PURE-LET 0 , PURE-LET 1 AND PURE-LET 2.We will use PURE-LET 2 schemes.

5. Mean square error (MSE)

The mean square error (MSE) is the error metric used to compare image quality. The MSE represents the cumulative squared error between the compressed and the original image, mean square error (MSE) is given by [17]

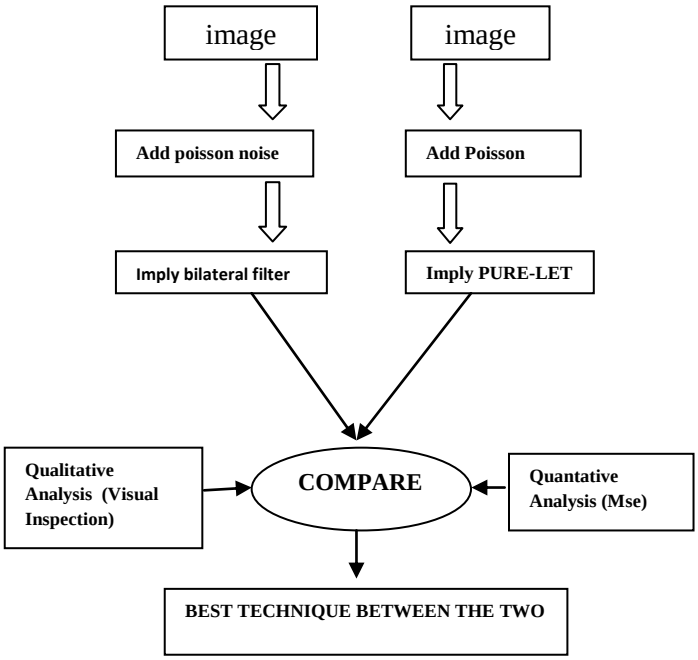
$$\mathbf{MSE} = \frac{\sum \boldsymbol{M,N}[\boldsymbol{I_1(m,n)} - \boldsymbol{I_2(m,n)}]^2}{\boldsymbol{M * N}}$$

M and N are the number of rows and columns in the input images.

6. Methodology

First the medical images are corrupted with poison noise, then imply bilateral filter and PURE-LET 2 on the corrupted images & finally do comparative analysis. Fig.1 shows the algorithm.

Figure 1. Comparison of bilateral and PURE-LET image denoising techniques



7. Result and discussion

Random medical images are taken from google. These medical images are made corrupted with shot noise. Then imply bilateral filter. Bilateral filter is set to w= 5(bilateral filteral half width) and standard deviation [3 0.1] respectively. Similarly imply the PURE-LET 2 on corrupted poisson images. The no. of wavelet scaled J=5, PURE-LET 2 is used. no of cycle spin = 5 respectively. Figure 2 shows set of medical images. Figure 3 shows medical images corrupted by shot noise. Figure 4 shows result of bilateral filtering, figure 5 shows result of PURE-LET 2. Table 1 shows quantitative analysis of medical images by computing mean square error

Figure 2. Original Medical Images

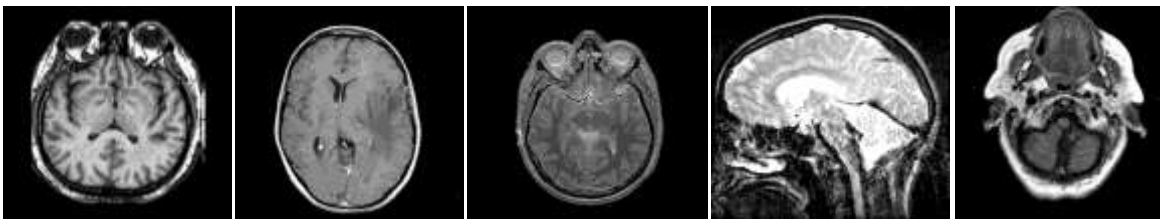


Figure 3. Poisson Noise Corrupted Images

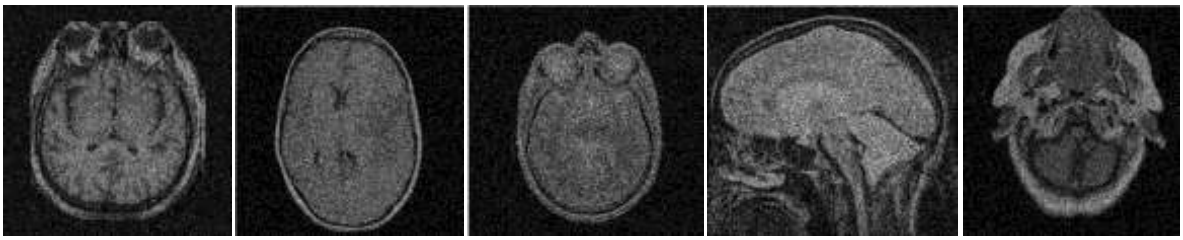


Figure 4. Result of Bilateral Filter

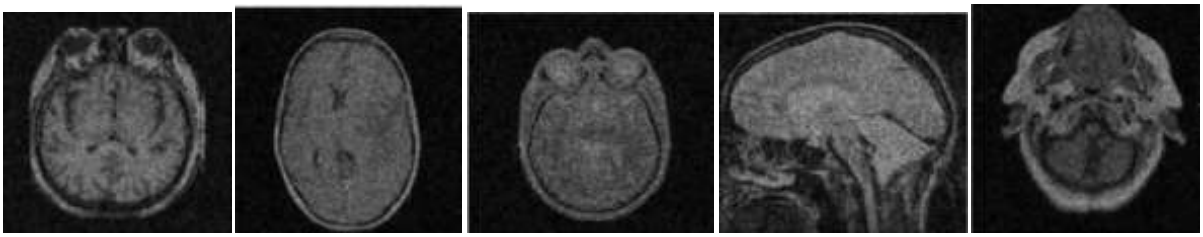


Figure 5. Result of Pure-Let 2

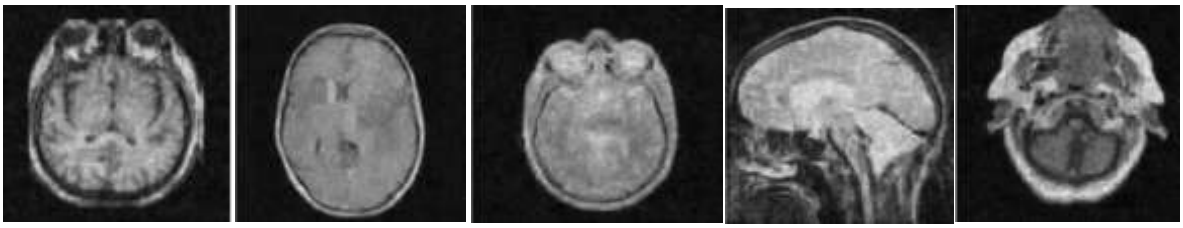


Table1.Quantative Analysis

images	MSE between poisson corrupted images and processed images by bilateral filtering	MSE between poisson corrupted images and processed images by PURE-LET 2	MSE between original images and corrupted poisson images
1	515.8725	1.9832e+03	2.4406e+03
2	1.7896e+03	1.7511e+03	2.7238e+03
3	1.2303e+03	2.2331e+03	2.5097e+03
4	1.0809e+03	2.6253e+03	4.4305e+03
5	1.2474e+03	2.2674e+03	2.5407e+03

Table 1 Shows quantitative analysis of medical images by computing mean square error

8. Conclusion

The diagnostic quality of medical images is very much reduced after implying both the techniques but PURE-LET 2 is better than bilateral filtering. In majority of cases MSE between Poisson corrupted images and processed images by PURE-LET 2 is greater than MSE between Poisson corrupted images and processed images by bilateral filtering.

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The Publication fee is defrayed by Indian Society for Education and Environment (iSee). www.iseeadyar.org

Citation:

Anush dogra, Ayush dogra. Medical image denoising by bilateral filtering & Pure-let for corrupted poisson images. *Indian Journal of Innovations and Developments.* Vol 4 (1), 100-103, January, 2015