Noise Removal From Brain CT Images

Computer Science

KEYWORDS : Medical Imaging; Filters; Peak Signal to Noise Ratio; Mean Square Error; Signal to Noise Ratio; Execution Time (ET);

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ABSTRACT

Image analysis is an important and challenging task in the computer-aided diagnostic systems. In medical image processing and especially in analysis task, it is very important to pre-process the image. Noise contained in brain images throttle both, the visual interpretation by experts as well as processing and analysis. This paper compares various standard filters for removing noise from brain CT scan images. This improves their performance in analysis task and also in visual quality of the images. We compared the filters by evaluating the brain images in terms of Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE), Signal to Noise Ratio (SNR) and Execution Time (ET).

INTRODUCTION

Medical imaging plays an important role in patient diagnosis [1]. To examine the disease of the patient various imaging modalities are used. Medical imaging techniques for brain scan like MRI, CT scan, are the tools used for extracting information by the radiologist. Computer-aided diagnosis system's main purpose is to assist physicians in the detection of abnormalities and diagnosis and it also provides second opinion [2].As compared to the other techniques used, CT scan is preferred because of wide availability, low cost and better contrast [3].

Noise reduces the quality of an image, if the brain CT image is very noisy then it will be very difficult to differentiate normal tissue and abnormal tissue and because of this there may be possibility of misdiagnosis. So image de-noising represents the crucial step in medical image analysis [4]. Noise or unwanted signals are caused by inadequate temperature, humidity, presence of small dust particles within the computer resulting inaccuracy in the reconstruction algorithm. Disregarding the causes of the noise, suitable filters are required for removing the noise so that further analysis of the image gives high degree of accuracy and reliability.

Two important characteristics of CT imaging that affect image quality are blur and noise [5]. The blur limits the ability to see small objects, boundaries of different tissue types and other image details. Image noise is the random variation of brightness or information in images produced by the sensor and circuitry of a scanner. These unwanted fluctuations give an image a mottled, grainy, textured, or snowy appearance. Increasing the radiation dose for better quality CT images can reduce the noise but increase the risk of inducing cancer. It is a trade-off to find the balance between reducing blur effect, reducing noise effect and avoiding harm to patients. Noise is often described by its probabilistic characteristics and generally there are different types of noise patterns depending on the distribution of noise over image data. The common noise patterns that are present in medical images are Gaussian noise [6], Salt and Pepper noise [7], Speckle noise [8] and Rican noise [9].

METHODOLOGY

The objective of this work is to find out de-noising techniques to remove noise from brain CT images while retaining as much as possible the important features [10]. There are various filters in literature for filtering medical images for different purpose and with different capacities. Out of many filters, to carry out the present study, we analyzed some standard filters like Max, Min, Mean, Geometric Mean, Harmonic Mean, Median, Hybrid Median, Gaussian and Weiner filters to remove noise from brain CT images. We compared their performance on the basis of estimation parameters as well as by visual quality of input images and de-noised images. Filters with the best performance are chosen for the image analysis system.

The statistical parameters are calculated from the original and filtered image and image quality measures are determined [11]. The entire purpose of estimation of parameters is to arrive at a filter that is easily implementable produces an estimate of the parameters with the corresponding accuracy. The parameters are Signal to Noise Ratio (SNR), Mean Square Error (RMSE) and Peak Signal to Noise Ratio [12].

A. Estimation of SNR

SNR compares the level of desired signal to the level of background noise. The higher the ratio of SNR, the background noise is less obtrusive. SNR is defined as:

$$SNR=10Log_{10}\frac{\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}[I(i,j)]^2}{\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}[I(i,j)-f(i,j)]^2}$$

where I(i, j) is the original image, f(i, j) is the filtered image and M * N is the dimension of the images.

B. Estimation of MSE

MSE (Mean square error) is an estimator in many ways to quantify the amount by which a filtered image differs from noisy image. If the value of MSE is low, we can say the quality of the image is better. The MSE is defined as:

$$MSE=\frac{1}{M*N}\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}[I(i,j)-f(i,j)]^2$$

where I(i, j) is the original image, f(i, j) is the filtered image and M * N is the dimension of the images.

C. Estimation of PSNR

PSNR is the ratio between possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. PSNR is defined as:

$$PSNR= 10\ Log_{10}\frac{Max(I(i,j))^2}{MSE}$$

where Max(I(i, j)), is the maximum possible pixel value of the image. When the pixels are represented using 8 bits per sample, then value is equal to 255.

D. Execution Time

Execution Time (ET) of a filter is defined as the time taken by a digital computing platform to execute the filtering algorithms when no other software, except the operating system runs on it. Execution time (ET) depends essentially on the computer system's clock, memory size and the input data size. However, the measure ET is very important because execution time taken by a filter should be very less for medical image analysis.

RESULT AND DISCUSSION

The entire methods were implemented in MATLAB 7.1 on Window 7. Computer configuration consists of 2.93 GHz CPU, 4 GB of RAM and 1GB graphics Card. The images are from CT machines and downloaded from internet but with different resolutions. Selected images were normal images and abnormal images having abnormalities of different sizes, shapes. These images were filtered by using nine standard filters like Mean, Harmonic Mean, Geometric Mean, Max, Min, Median, Hybrid Median, Gaussian and Weiner filters available in MATLAB. The same procedure is followed in each individual filtering experiment. Analysis of the various image de-noising techniques dealt with the performance parameters like mean square error (MSE), peak signal to noise ratio (PSNR), signal to noise ratio (SNR) and Execution time (ET). It is proposed to obtain higher values of PSNR and SNR whereas MSE, ET value must be low for better image quality.

Table-1 and Table-2 shows the CT images acquired from hospital, these are normal brain image and containing epidural hemorrhage (EDH) respectively. Table-3 and Table-4 shows images of subdural hemorrhage (SDH) and intracerebral hemorrhage (ICH) respectively downloaded from the internet. From the Tables(1-4) we observed that the Median, Hybrid Median, Gaussian and Weiner filters are comparable in terms of MSE and PSNR. But ET of Hybrid Median filter is very high and ET of Weiner filter was slightly higher than the others. In terms of PSNR, SNR, MSE and ET, Gaussian filter outperformed the other filters.

We applied all these filters on all the dataset and our comparison of filters does not depend solely on images shown above (Tables 1-4).Due to some variations in image quality, intensity values, contrast and artifacts in the images the results obtained from all the filters may vary. But on an average Gaussian filter works well on all the images in the dataset. Our result and conclusion of choosing the Gaussian filter for removing the noise was taken after analyzing all the 100 images in dataset of brain CT images.

It was also concluded from the results that the CT images collected from the hospital and CT images downloaded from internet had Gaussian and Impulse noise respectively. Another outcome is that the images collected from hospital were very smooth and noise level in the images are very low. MSE between the original and filtered image is very less in all the filtered images, indicating that in CT scan machine reconstruction software itself includes some noise removing filters that gives high quality images. But the images downloaded from internet have more noise level.

TABLE 1: Comparison of various filters on the basis of PSNR, MSE, SNR, ET for CT image having EDH

	Filters	PSNR	SNR	MSE	ET
Image (512X512)  EDH	Mean	70.0346	67.3516	0.0065	0.0156
	Harmonic Mean	65.163	62.4806	0.0198	0.9828
	Geometric Mean	68.2389	65.5560	0.0098	0.2964
	Median	74.0331	71.3501	0.0026	0.0468
	Hybrid Median	73.9818	71.2988	0.0026	1.198
	Min	66.0486	63.3656	0.0162	0.9672
	Max	65.163	62.4806	0.0198	0.9828
	Gaussian	81.5066	78.8237	0.0005	0.0312
	Weiner	89.11	87.2288	0.0001	0.734

TABLE- 2: COMPARISON OF VARIOUS FILTERS ON THE BASIS OF PSNR, MSE, SNR, ET FOR NORMAL BRAIN CT IMAGE.

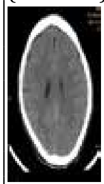
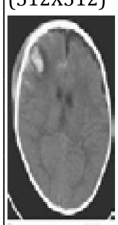
	Filters	PSNR	SNR	MSE	ET
Image (512X512)  Normal	Mean	76.0731	77.6255	0.0016	0.0312
	Harmonic Mean	65.17	62.4806	0.0198	0.9828
	Geometric Mean	74.851	76.4105	0.0021	2.168
	Median	83.7196	85.2720	0.0003	0.0468
	Hybrid Median	79.691	81.2434	0.0007	1.256
	Min	70.5301	72.0826	0.0058	1.81
	Max	70.1749	71.7274	0.0062	1.9188
	Gaussian	88.4095	89.9619	0.0001	0.0468
	Weiner	88.1775	85.3277	0.0001	0.4092

TABLE-3: Comparison of various filters on the basis of PSNR, MSE, SNR, ET for CT image having SDH

	Filters	PSNR	SNR	MSE	ET
Image (512X512)  SDH	Mean	76.9562	74.1696	0.0013	0.0312
	Harmonic Mean	73.1950	67.4416	0.0031	0.2964
	Geometric Mean	75.2865	69.5332	0.0019	0.176
	Median	88.581	85.7985	0.0001	0.0468
	Hybrid Median	85.2903	82.5037	0.0002	1.4316
	Min	71.585	68.3992	0.0049	0.7176
	Max	71.1413	68.3547	0.0050	0.6862
	Gaussian	84.9825	79.2291	0.0002	0.0468
	Weiner	90.3717	87.5851	0.0001	0.5568

Table- 4: Comparison of various filters on the basis of PSNR, MSE, SNR, ET for CT image having ICH

	Filters	PSNR	SNR	MSE	ET
Image (512X512)  ICH	Mean	69.6244	58.2697	0.0071	0.0312
	Harmonic Mean	71.5554	60.2006	0.0045	0.0312
	Geometric Mean	74.0816	62.7269	0.0025	0.0152
	Median	79.8778	68.5231	0.0007	0.0468
	Hybrid Median	76.3533	64.9986	0.0015	0.9667
	Min	65.2775	53.9228	0.0193	0.0936
	Max	65.2419	53.8871	0.0194	0.078
	Gaussian	83.8212	72.4665	0.0003	0.0312
	Weiner	81.4976	70.1428	0.0005	0.8682

The other important comparison is visual quality, as the edges must be preserved in filtering for some medical image analysis applications. The Median filter qualifies among these filters as the Gaussian and Wiener filters [13] blur the edges than the Median filter [14]. So depending upon the requirement of medical image analysis application Gaussian or Median filter will be chosen.

CONCLUSION

The main problem during medical image analysis is the noise present in the images and in this paper, we have demonstrated the performance of nine de-noising filters. The performances was evaluated in terms of Peak signal to noise ratio (PSNR), Mean square error (MSE), Signal to noise ratio (SNR) and Execution time (ET). It is concluded that the brain CT images collected from the hospital were very smooth and noise level is very low and had Gaussian noise. Brain CT images downloaded from internet were grainy and had Impulse noise. So depending upon the requirement of medical image analysis application Gaussian, Median or Weiner filters can be chosen as their performances are better than the other filters. Gaussian filter should be chosen to remove gaussian noise and Median filter is chosen to remove salt and pepper noise and where sharp edges must be preserved. Weiner filter should be chosen to remove speckle noise.

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