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Comparative Study of Filtering Techniques on Lung CT Images

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ABSTRACT
Lung cancer is a deadly illness that causes people to die. Accurate classification and differential diagnosis of lung cancer are currently important for the stability and precision of cancer identification. The noise and other variables degrade the CT images which may causes inaccurate diagnosis. Denoising methods also knows as filtering methods are very effective in order to increase quality of an image. In this paper different filtering techniques were compared. Various evaluation parameters like Peak Signal to Noise Ratio (PSNR), Image Enhancement factor (IEF), Image Quality Index (IQI), Structural Similarity Index (SSIM) are calculated for all the algorithms and comparative analysis is carried out.
Keywords: Lung Cancer, Computed Tomography, Image Denoising.

I. INTRODUCTION

Lung cancer is a crucial source of universal cancer-related deaths [1]. In men and women lung cancer is second common cancer (not considering skin cancer) both small cell and non-small cell. Prostate cancer is more common in men, while it is more common in women with breast cancer. Approximately 13% of recently introduced cancers are lung cancers [2]. In order to limit death rate because of lung cancer its identification at initial stage is the only option [3]. However, to find out lung cancer at its initial stage is difficult stage and for which the physician asks patients to submit regular intervals to several computed tomography (CT) images. As these CT Images are noisy because of electrical signals, mathematical computations and quantum statistics [4]. So, before any conclusion using automated system it is expected to remove noise. There is basic three techniques to monitor or decrease the noise of CT images, namely projection, iterative reconstruction and Denoising post-processing-based images [5].

A successful image filtering model's dominant feature is that it can totally suppress noise, as well as retain edges and details [6]. There is usually no particular noise reduction strategy, but each and every filtration method has its own benefit and disadvantage during the denoising process [7]. A research area is still being focused on to retain the detailed information in medical images when processing and working with them.

The purpose of this study is to analyze the efficiency of the technique reviewed above on the CT picture of the lung that is distorted by different noise.

Denoising of image can be processed in spatial as well as in frequency domain. The various denoising techniques have been discussed in literature. The most popular is median filter to remove salt and pepper noise with minimum artifacts [8]. Section II is described by various types of spatial filtering techniques.

II. DIFFERENT FILTERING TECHNIQUE

Image filters are broadly classified as linear and nonlinear [9]. As explained below, the various filtering methods used to denoise the image are

A. Average Filter

The average filter is used to reduce an image's intensity. The mask is used for processing a noisy image. The mask has a particular size that, by considering the neighborhood pixels, determines the average. The middle pixel of the mask is replaced by the average value of its neighboring pixels. When the neighborhood of the filter extends to edges that can smooth the corners of an image [10].

B. Median Filter

The median filter is the nonlinear filter which performs the nonlinear operation of neighboring filter. it is very effective for salt and pepper noise and it preserves the edges. It also works on the neighborhood pixels. In this method, each pixel is replaced by a median value of its neighborhood pixel. It is very effective when the neighborhood considers is small while it causes blurring in an output image for the large neighborhood. Short comings of median filter can be overcome by Adaptive median filter. The benefit of this filter is that the noise is eliminated while the outer edges are retained.

C. Min-Max Filter

The Min filter substitutes the minimum intensity of the neighboring pixels for each pixel in the mask of size m x n. While Max filter substitutes maximum pixel intensity. The max filter is called as hundred percentiles while min filter is termed as zero percentile filter. Mathematical equation for min and max filter Both filters are given in equation 1 and 2 respectively.

F(m, n) = min {g (s, t)} --------------- (1)
Where (s, t) ϵ (m, n)
F(m, n) = max {g (s, t)} --------------- (2)
Where (s, t) ϵ (m, n)

D. Bilateral Filter

A bilateral filter is an image smoothing filter that is non-linear, edge-preserving, and noise-reducing. It replaces each pixel's intensity with a weighted average of neighbouring pixel intensity values.

E. Anisotropic Diffusion Filter

Without blurring edges from digital image anisotropic diffusion filter is used. If the coefficient of diffusion is constant then anisotropic diffusion filter minimizes to Gaussian blurring [11].

III. MATERIALS AND METHODS

In this paper, CT images denoising method experiments were performed on the computer with Intel® Core™ i3 CPU at 2.8 GHz, 8GB RAM, Windows 10 Home 64. Implementation of proposed algorithm was done using MATLAB (R2014a) software.

Data Collection:

The images are collected from Lung Image Database Consortium (LIDC). The helical CT scan images are obtained at 120KVp (Kilo Voltage peak distribution). This Image is stored in DICOM format as in [14]. The slice image of thorax CT scan is usually 512x512 pixel resolution DICOM images are read (using MATLAB tool) as matrices of 16-bit integer data type. In this method, the data type conversion is also omitted.

IV. EXPERIMENTALRESULTS

Output of experimental results (images) have been shown in Table- I, using averaging, median, bilateral and anisotropic filter for different types of noise. Images used in this comparative analysis have taken from widely used standard database. For simulation purpose we have corrupted the CT images by adding noise and then we have applied all the filters mentioned in section II.

Table II: CT image denoised using Averaging

Parameter	Salt & Paper	Speckle	Poisson	Gaussian
PSNR	65.82286	67.53000	76.47171	68.74493
IEF	4.73837	3.09502	0.00000	3.13328
IQI	0.51078	0.55591	0.80098	0.55752
SSIM	0.6145	0.6847	0.9034	0.6586

Table III: CT image denoised using Median

Parameter	Salt & Paper	Speckle	Poisson	Gaussian
PSNR	17.49807	18.97828	26.61268	20.66580
IEF	22.32664	2.48289	1.64774	3.40724
IQI	0.99922	0.99804	0.99947	0.87019
SSIM	0.9409	0.5876	0.8548	0.6300

We have calculated the values of Peak Signal to Noise Ratio (PSNR), Image Enhancement factor (IEF), Image Quality Index (IQI) and structural Similarity indexmeasure (SSIM).
After performing simulation, the Table II, III, IV and V shows the values of PSNR, IEF, IQI and SSIM by applying averaging, Median, Bilateral and Anisotropic diffusion filters respectively

Table IV: CT image denoised using Bilateral

Parameter	Salt & Paper	Speckle	Poisson	Gaussian
PSNR	39.09454	38.03752	35.43028	37.53561
IEF	0.99580	1.09242	1.78724	1.23509
IQI	0.96289	0.99790	0.99960	0.95337
SSIM	0.4110	0.4662	0.8125	0.3978

Table V: CT image denoised using Anisotropic diffusion

Parameter	Salt & Paper	Speckle	Poisson	Gaussian
PSNR	34.43878	27.59942	28.39530	26.78917
IEF	0.98694	1.28072	2.76356	1.82187
IQI	0.95844	0.99433	0.99690	0.95302
SSIM	0.3839	0.6023	0.8958	0.4852

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V. CONCLUSION AND FUTURE WORK

In this work comparative study of Averaging, Median, bilateral and Anisotropic diffusion filtering algorithms is carried out for lung CT images. In future modern filtering methods based on Neural Networks and optimization techniques like Random Forest can be implemented for better results with deep learning.

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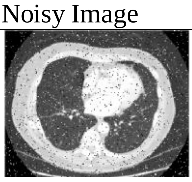
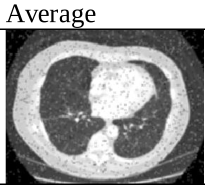
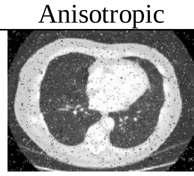
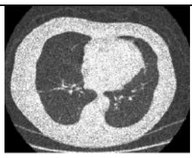
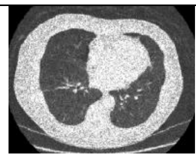
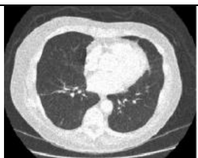
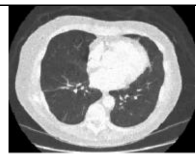
TABLE I
Comparative analysis of lung cancer classification

Images	Noisy Image	Median	Average	Bilateral	Anisotropic
Salt and Paper					
Speckle					
Poisson					
Gaussian