International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-06, Issue-10, JAN 2021

An Optimum filter to suppress the noise in Abdominal CT images

M Jayanthi , Associate Professor, New Horizon College of Engineering , Bangalore, India
jayanthisathish1012@gmail.com
Chanda V Reddy , Professor and Head , K S Institute of Technology , Bangalore , India
chandavreddy@ksit.edu.in

Abstract: **In medical imaging, noise is an important factor which degrades the quality of an image. The importance of medical imaging is to view the internal structure of human anatomy. Due to the acquisition process, noise degrades the visual quality of medical imaging. This noisy image affects the visual evaluation, suppresses the edge and boundaries details. These factors limit computer system to discover diseases in medical images. To enhance the quality of an image and to suppress the noise, preprocessing is an essential step in Computer Assisted Diagnosis System. In this paper, we propose an optimum noise removal filters to suppress the noise in abdominal CT images. The optimum filter is a hybrid combination of bilateral and wiener filter. The proposed method helps o improve the segmentation and classification accuracy. For performance evaluation of optimum filter, various quality metrics are taken for analysis and compared with existing denoising filters.**

Keywords* —Acquisition process, Denoising filters, *CT, Noisy Image, Optimum Filter, Quality metrics

I. INTRODUCTION

CT stands for Computed Tomography, which is also called as Computerized Axial Tomography (CAT). This imaging is a non invasive radiation based inspection procedure that generate three dimensional view of an image from massive series of two dimensional image taken on a cross sectional area of the human body. CT scan and Multi slice CT image [1] is shown in Figure 1.The word Tomography comes from Greek words "Tomos" and "Graphia". The meaning of "Tomo" is slice or cut to or section. The word "Graphia" indicates writing or description. CT scan uses X-ray source and emits X-ray beam through the human body, in order to study the anatomical information of it.

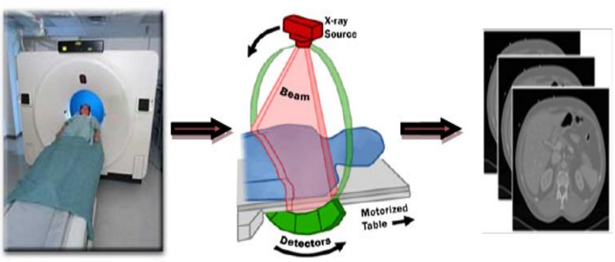

Figure 1:CT scan and multi slice CT image [1]

CT scanner has motorized X-ray tube, specialized metal detector and gantry. The X-ray tube is placed exactly opposite to a metal detector that rotates around the gantry. This tube shoots the beam of X-ray through the patient body. These signals are picked up by a row of metal detector. The signal from a detector are then converted to an electrical signal and thus converted to digital by means of Analog to Digital Converter (ADC). On a CT film, dense tissue or hard tissue appears white. Whereas soft tissue like liver appears grey and lungs cavity that are filled with air space appear black.

CT abdominal images are collected from different sensors of CT scanner. These images are fully contaminated and disturbed with a different type of noises. The noise includes Gaussian noise, poisson noise, speckle noise and impulsive noise. The corrupted medical images are due to the following reasons:

- Presence of ambient noise from environment.
- Noises coming from the machine or equipment during the diagnostic examination process.
- Patient's breathing motion.
- Noise due to the movement of internal tissue like fat and other organs.

Table 1: Occurrence of various noises

Noises	Possibilities of occurrence
Gaussian Noise	Acquisition process
Poison Noise	Transmission process
Impulsive Noise	Image capturing process
Speckle noise	Occurs during transmission and reception process

 DOI : 10.35291/2454-9150.2021.0021

The most important noise source in CT imaging is Gaussian noise and poisson noise. The occurrence of Gaussian noise is more in CT image due to the additive effects of patient movement, insufficient sensor temperature and poor light level intensity during the acquisition process. Table 1 shows the occurrence of various noises.

Generally, CT images are influenced by blurring and noise effects. The clarity of small objects is diminished by blurring effects. But noise reduces visibility of low contrast objects. Radiation dose used in CT scan is directly proportional to current through the x-ray tube. If the radiation dose is decreased then the noise is more. Excess noise; degrade the image quality of CT image. If the radiation dose is increased then there is a high risk factor of cancer. If the image is noisy, then it is difficult to differentiate the normal and abnormal tissue. Not only that, Noisy image affects the performance of segmentation, feature extraction and classification. For Computer Assisted System, low quality image are not effective, which leads to inaccurate results. So Noise removal from abdominal CT images is very much essential for correct diagnosis.

II. Literature Survey

The acquired CT image has many artifacts due to the usage of various sensors in the CT scanner machine. This undesirable information might degrade the quality of the medical images. In order to improve the quality of the image and to suppress the noise, preprocessing is essential. This section helps to understand the different types of preprocessing filters that are developed by various researchers.

Narain et al. [2] have presented and reviewed a detailed analysis of various preprocessing techniques for the suppression of noise in the medical image. In addition to this, the authors have proposed a novel method to remove the high rectangular label and tape artifacts. This method blurs the images because of severe smoothening. Sonali Patil and Udupi [3] have discussed the importance of preprocessing filters for CT and MRI images. The authors have presented this technique to remove the film artifacts and to remove unwanted portion in the medical image. This method removes only specific artifacts, which will not improve the segmentation efficiency. Tarandeep et al. [4] have reported comparative analysis of denoising filter to suppress the noise in the brain CT images. The authors have used anisotropic filter for the suppression of non Gaussian noise. The authors realized the importance of wavelet based denoising filter by considering the local information of an image. This filter takes more time to converge, because of iteration process and it is more suitable for brain CT images.

Vijaya and Suhasini [5] have proposed various preprocessing filters to suppress the noise present in CT images. The authors have considered both linear and non linear filters for performance evaluation. The authors have not revealed the noise in the CT images. Senthilraja et al. [6] have developed hybrid filter that combines Wiener and bilateral filter. This filter focuses on the removal of speckle and Gaussian noise present in CT spinal image. The optimized bilateral filter has been implemented by Saime [7]. This method suppresses the Rician noise present in MRI image. The authors have used a genetic algorithm to select the filter parameter of bilateral filter. This method gives significant improvement in terms of noise suppression and edge preservation, but the convergence rate is more.

All the researchers have clearly discussed about the importance of denoising filters. The excessive noise will degrade the quality of the medical image and causes blurring effect. Most of the times end up with inaccurate results. So preprocessing is a prerequisite in a future process of Computer Assisted System.

III. Proposed Methodology

The various denoising filters are implemented in this work. The procedure to implement EPOF filter is discussed in below section and sequential flow is shown in Figure 2. The various steps to suppress the noise are listed below. The best filter is chosen based on PSNR and MSE.

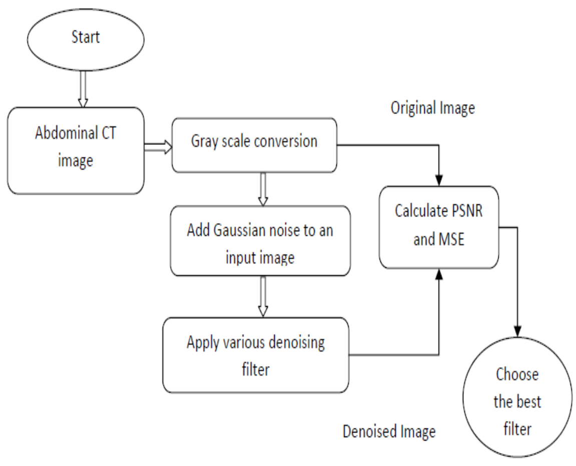

Figure 2 : Sequential flow of preprocessing filter

Step 1: Convert original CT image to gray scale.

Step 2: After the conversion, uniformly add some amount of noise to all the images in the database.

Step 3: Apply the following filters: Mean, median, Gaussian filter, Bilateral and proposed EPOF filter. In case of EPOF filter, set of tuning parameters are initialized. Three set of samples are taken for kernel coefficient. These parameters are used to obtain edge preserving filtered output. Later,

 DOI : 10.35291/2454-9150.2021.0021

ISSN : 2454-9150 Vol-06, Issue-10, JAN 2021

three set of filtered outputs are given to optimum filter. This filter will find the best parameter that gives good PSNR.

Step 4: Find Mean square Error (MSE), Peak Signal to Noise Ratio (PSNR) and Image enhancement Factor (IEF).

Step 5: Select preprocessing filter which has low MSE and high PSNR.

IV. EDGE PRESERVING OPTIMUM FILTER (EPOF)

The main objective of this filter is used to suppress the noise in medical images and produce the optimum results. To achieve this, EPOF combined the concepts of edge preservation and minimizing the error between estimated and desired filtered output. This filter has two stages. First stage concentrates on preserving the edges. So edge preserving bilateral filter is used in this stage. Second stage uses wiener filter to minimize the error. So EPOF is a nonlinear non iterative bilateral filter.

The step by step procedure for the implementation of EPOF filter is discussed below.

Step 1: Let an input image be 'V' and pixel value of the image at each position is Vp.

Step 2: Set the window size.

Step 3: Initialize the set the tuning parameter for Bilateral filter (σsd,σid).

Step 4: Calculate spatial distance noise using equation 4.3.

$$s_d(p,q) = e^{-\|p-q\|^2/2\sigma_{sd}^2} \quad \text{-------- Eq (1)}$$

Step 5: Gaussian intensity weight is calculated as

$$I_d(p,q) = e^{-|V(p)-V(q)|^2/2\sigma_{id}^2} \quad \text{---------Eq (2)}$$

σsd and σid are used as Gaussian controlling kernel coefficient. σsd is proportional to image size that controls spatial distance. and intensity difference. σid controls difference in the intensity and proportional to edge amplitude.

Step 6: At each pixel point ,bilateral filter output is computed as

$$Bif(p) = \frac{1}{c}\sum_{q\in\gamma(p)} Bif(q)s_d(p,q)I_d(p,q) \quad \text{--------Eq (3)}$$

Where C is a normalization factor $c = \sum S_d(p,q)\, I_d(p,q)$ and $\gamma(p)$ shows the spatial neighborhood of Bif(p). Each pixel is replaced by the weighted average of nearby pixels in spatial neighborhood.

Step 7: For optimum wiener filter, Calculate the mean and standard deviation using equation

$$\mu = \frac{1}{pq}\sum_{p,q\epsilon w} I_o(p,q) \quad \text{---------Eq (4)}$$

$$\sigma^2 = \frac{1}{pq}\sum_{p,q\epsilon w}(Io^2(p,q) - \mu^2) \quad \text{---------Eq (5)}$$

Step 8: Calculate the optimum filter output using 4.8

$$I(x,y) = \mu + \frac{\sigma^2 - v^2}{\sigma^2}(I_o(x,y) - \mu) \quad \text{---------Eq (6)}$$

Step 9: Equation 4.9 shows combined filter output equation

$$E'(f) = \iint_{-\infty}^{\infty} E(f)[Bif(x) + I(x)]\, dx\, df \quad \text{--Eq(7)}$$

To understand proposed filter, consider an input image of size 3x3.For a given input, calculate spatial distance and intensity difference. Then weighted value is multiplied with an input image to get edge preserving filtered output. The construction of proposed filter is shown in Figure 3.

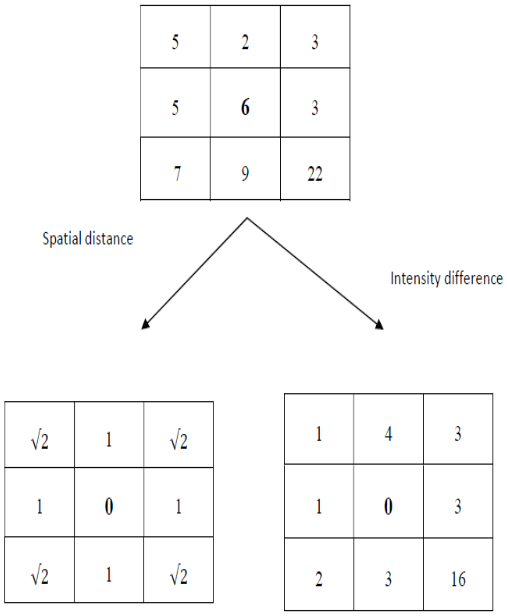

Figure 3: Illustration of edge preserving filter

V. EXPERIMENTAL RESULTS AND DISCUSSION

The proposed method is compared with different denoising filter in order to enhance the contrast of CT images. The database consists of real and stimulated images. Real images are collected from radiology archives [16] and simulated images are collected from private datasets. Each patient has more than hundred slice and more than one phases of CT scan (arterial, non contrast, delayed, portal venous). Middle slice is preferable; it contains more information because X-ray source and metal detector exactly middle in the CT scanner. The portal venous is same as an axial image. The proposed work runs for 60 images. All images are in DICOM format. Using Acculite software, these DICOM images are converted to JPEG format. These database images have different dimension and resolution.

 DOI : 10.35291/2454-9150.2021.0021

ISSN : 2454-9150 Vol-06, Issue-10, JAN 2021

The slice thickness of database images varies from 0.5mm-10mm. The proposed work is implemented using MATLAB software with the processor speed of 1.8GHz and 2 GB RAM.

Table 2: Parameter Selection

Preprocessing Filters	**Window size**	**σsd**	**Σid**
Mean Filter(MF)	5	-	-
Median Filter(MEF)	5	-	-
Gaussian Filter(GF)	5	3	-
Bilateral Filter(BF)	5	3	0.1
EPOF	5	[3-5]	[0.1-0.6]

Before initializing the experiment, CT images in the database are corrupted with Gaussian noise of different noise levels ranging from 0.01 to 0.05. All the tuning parameters that control the blurring are initialized. The parameter selection of all the filters is shown in Table 2. But the proposed method (EPOF) is a combination of two filters. This filter requires set of tuning parameters that improve the efficiency of proposed method in comparison with other methods.

All the methods use this parameter selection to obtain the filtered output. Sample results of preprocessing techniques [10-11] are shown in Figure 4. Figure 4.a is a original CT image. Totally, five preprocessing filters are taken to rebuild the quality of CT images. Figure 4.b shows CT image corrupted by Gaussian noise with 1% noise densities. Figure 4.c shows the result of mean filter and it is not clear. It is observed that, this filter shows blurring effect because high frequency components are attenuated. Figure 4.d shows the result of median filter from which it is inferred that it gives better quality compared with mean filter. But the fine details are not preserved and some amount of noise is recorded in the output. Figure 4.e exhibits the Gaussian filter output and this filter completely suppressed the noise but it has introduced over smoothening in CT images. Figure 4.f illustrates the output of bilateral filter and this filter restores the edges and also preserves the boundaries. Figure 4.g shows the output of proposed method and this filter strengthens the edges and also provides good quality improvement that highly relies on tuning parameter. The results have revealed that EPOF suppresses the noise and to give better results and it is more suitable for segmentation. The above discussion is done in the view of visual perception. But this does not give precise results. So the quantitative analysis is required.

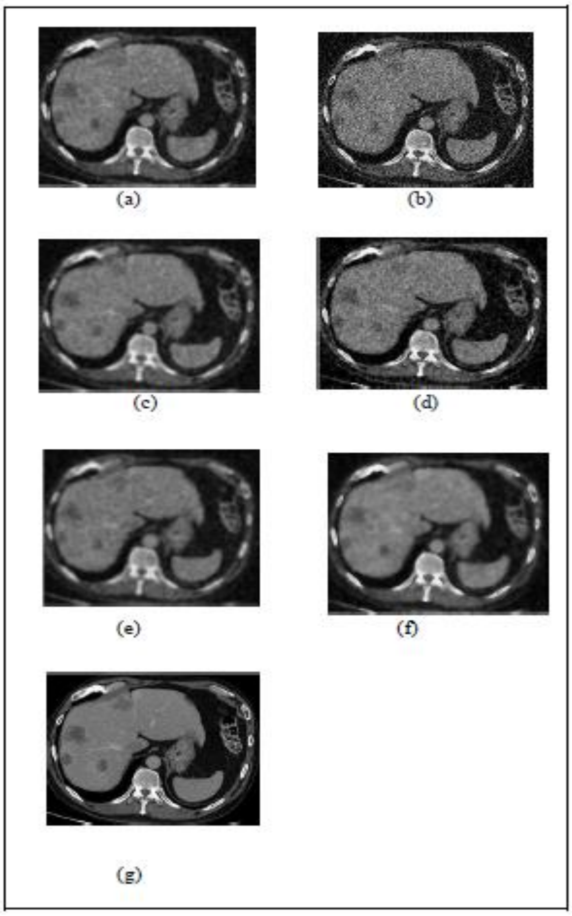

Figure 4 : Results of preprocessing techniques

A. Performance metrics

The following performance metrics are considered for evaluating assessment of the proposed method.

Mean square error [12-14] explains how the information of two images is differed.

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}\|Org(i,j) - den(i,j)\|^2$$

-----Eq (8)

Where Org denotes original image without noise, den denotes filtered image after denoising, M and N represents the number of rows and columns. The next evaluation metrics is PSNR; computes quality of two images by utilizing the error measurement concepts. PSNR is measured in decibel (dB).

$$PSNR = 10 * log_{10}\frac{max^2}{MSE} = 20 * log_{10}\frac{255}{\sqrt{MSE}}$$

-------Eq (9)

Where max= 255 indicates maximum gray value of an image and MSE is a mean square error. The last performance metric is image enhancement factor (IEF) provides dynamic extent of intensity values additionally gives interpretation of image information like human viewers. IEF can be calculated as

 DOI : 10.35291/2454-9150.2021.0021

$$IEF = \frac{\sum_i \sum_j (no(i,j) - Or(i,j))^2}{\sum_i \sum_j (de(i,j) - Or(i,j))^2}$$

---Eq (10)

Table 3 explains the various preprocessing filter in terms of PSNR with different noise levels. This table implies that performance of reconstruction filter goes down when the noise density levels increases.

Table 3: Comparison of PSNR with different preprocessing filters

Preprocessing Filter	1%	2%	3%	4%	5%
MF	24.56	23.5	23.41	22.61	21.5
MEF	25.6	24.86	23.83	22.56	20.32
GF	26.37	24.33	24.31	22.14	19.63
BF	26.347	25.53	25.48	23.34	21.54
EPOF	32.05	30.48	30.56	26.12	25.21

Figure 5 shows the plot between noise level and PSNR and it is concluded that the filter performance degrades the quality of CT image as noise density increases.

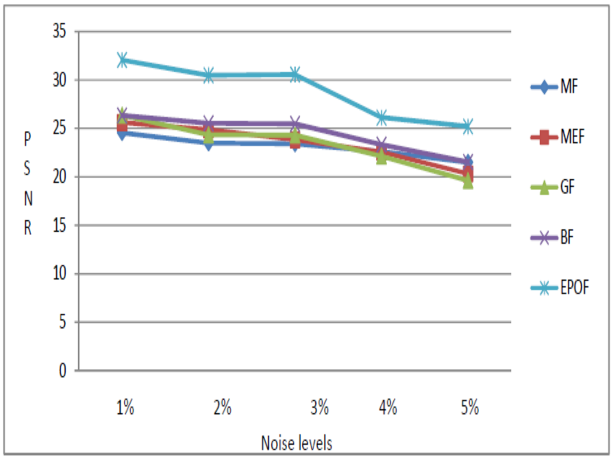

Figure 5: Performance plot between noise levels and PSNR.

Table 4 shows the comparison of preprocessing filter based on performance metrics. The proposed method is a combined effect of edge preserving and optimum filter. Both the filters preserve the edges and information parts of high frequency components in an image. Hence this method, shows a better result in terms of IEF and PSNR, but also shows a good result in terms of visual and human perception.

Table 4: Comparison of quantitative metrics with proposed method

Metrics	Noisy Image	MF	MEF	GF	BF	EPOF
MSE	255.29	148.21	198.05	264.61	158.75	69.39
PSNR	24.06	26.42	25.16	23.9	26.123	34.71
IEF	6.46	18.3	43.12	40.7	53.06	87.23

VI. Conclusion

In this work, edge preserving optimum filter is proposed to improve the quality of CT abdominal images. This filter helps to preserve the edge information thereby minimizing the error between estimated and desired filtered output. Both real and stimulated images of abdomen are taken for experimental discussion. Most of the CT images are affected with Gaussian noise. The effect of this noise was seen during the acquisition process. The different preprocessing filters are taken and analyzed to suppress the Gaussian noise in the abdominal CT image. In simple words, image with low error gives better accuracy. Therefore, good denoised image has high PSNR and low MSE. The results revealed that proposed filter has outperformed and achieved 87.23% better results than traditional methods. In future, the work can also be extended for other types of medical images like MRI,PET.

References

[1] Pedro Chopite (2017), "single slice CT", https://www.quora.com/Whats-difference-between-Single-slice-CT-and-MultiSlice-CT/

[2] .D.Narain Ponraj, M.Evangelin Jenifer, P. Poongodi, J.Samuel Manoharan, "A survey on the preprocessing techniques of mammogram for the detection of Breast Cancer",*Journal of Emerging Trends in Computing and Information Sciences* ,Volume 2, No. 12,pp 556-564,2011.

[3] Sonali Patil, V.R. Udupi, "Preprocessing to be considered for MR and CT Images containing tumors" , *IOSR Journal of Electrical and Electronics Engineering*, Volume 1No. 4, pp 54-57, 2012.

[4] Tarandeep Chhabra , Geetika Dua, Tripti Malhotra, "Comparative Analysis of Methods to Denoise CT Scan Images", *International Journal of Advanced Research in Electrical*,Electronics and Instrumentation Engineering, Volume 2, Issue 7, pp 333-3369,2013.

 DOI : 10.35291/2454-9150.2021.0021

[5] G. Vijaya and A. Suhasini ,"An adaptive preprocessing of lung CT images with various Filters for Better Enhancement", *Academic Journal of Cancer Research* ,Volume 7 No. 3,pp 179-184, 2014.

[6] S Sentilraja, P suresh, M Suganthi , "Noise reduction in computer Tomography image using WB filter", *International journal of scientific and Engineering Research*, Volume 5,No.3, pp 243-247,2014.

[7] Sweety Deswal, Shailender Gupta, Bharat Bhushan "A survey of various bilateral filtering techniques", *International journal of signal, image processing and pattern recognition*, Volume 8, pp 105-210 ,2015.

[8] Kirti V.Thakur,Omkar H. Damodare,Ashok M.Sapkal ,"Poisson Noise Reducing Bilateral Filter", *Procedia Computer Science* Volume 79, pp 861 – 865, 2016.

[9] Saime Akdemir Akar, "Determination of optimal parameters for bilateral filter in brain .MRI Image Denoising", *Applied soft computing (Elsevier)*,Volume 43, pp 87-96,2016.

[10] M. Jayanthi, "Comparative Study of Different Techniques Used for medical image segmentation of Liver from Abdominal CT Scan", IEEE WiSPNET 2016 conference; pp. 1462-1465, 2016.

[11] Jayanthi, M., Kanmani, B., "Extracting the Liver and Tumor from Abdominal CT Images", IEEE, Fifth International Conference on Signal and Image Processing (ICSIP)", pp. 122-125, 2014.

[12] Jayanthi M ,"New Edge Preserving Hybrid Method for Better Enhancement of Liver CT Images", *Indian Journal of Science and Technology*, March 2017; Volume : 10, Issue:10; Pages: 1- 7.

[13] Jayanthi, M., Kanmani, B ,"Optimization based Liver Contour Extraction of Abdominal CT images" *International journal of Electrical and Computer Engineering (IJECE)*, Volume 8, Issue .6,2019.

[14] Usha Rani, "Decision Based Impulse Denoising Techniques for Gray Scale Images: An Experimental Analysis" *International Journal for Research in Engineering Application & Management (IJREAM)* Vol-04, Issue-11, Feb 2019.

[15] A.Nirmala, "Brain Tumor Image Segmentation Using Kernel Based Fuzzy C Means Clustering (KFCM) Algorithm", *International Journal for Research in Engineering Application & Management (IJREAM)* Vol-05, Issue-10, Jan 2020.

[16] The cancer Imaging Archive (TCIA), http://www.cancerimagingarchive.net/

 DOI : 10.35291/2454-9150.2021.0021