

An Analytical Study of Noise Removal Techniques on Various Types of Medical Images

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Abstract: Low-contrast images in medical imaging would be acquired commonly, which may interfere with the regular diagnosis. Improvement with enhancement is one of the key tools in medical image analysis. The enhancement during the preprocessing stage includes contrast improvement, brightness and noise removal or to provide enhanced input for further automated image processing procedures. The chief motive of performing the image enhancement is to reveal the hidden information in feature or to enhance the low contrast image. This study is yield in two different medical modalities CT-scan, and X-ray. Analytical computation of different filters between original image and filtered image by calculating PSNR and MSE of all these medical images shows the performance of filters. This experimental study which is performed, can improve the accuracy of medical images (X-ray, CT-scan) for easy detection of disease.

Key-Words: Low-contrast images, noise removal, PSNR, MSE

Introduction

Illustration of the human body is produced using medical imaging techniques which are intended for medical reasons and analysis. The X-ray and CT modalities have made it possible to recognize the occurrence of nodules. Anatomical and functional information of body is acquired through CT imagining system which uses X-ray but the quality of the image is influenced by abundant sources like camera sensors, communication channels, analog-to-digital conversion etc. These acquired images have very low contrast. For this reason, quality of the image needs to be augment by removing the noise [1]. The key role of noise removal is to not only eliminate the noisy components but also maintaining the essential detail of the image as much as possible. Consequently for applications of medical imaging in order to improve and get better the analysis of hidden details in the data, denoising plays a vital role [6]. Thus filtering is used to get clear images and to make possible the further processing such as analysis, finding of edges and segmentation etc. Filtering an image to attenuate noise while keeping the image details preserved is one of the most important issues. Consequently, there is a need for noise removal technique that removes different sort of noise like

- Poisson (Photon)
- Gaussian (Amplifier)
- Impulse (Salt and pepper)
- Uniform
- Rayleigh
- Exponential
- Gamma(Erlang)
- Speckle

This study focused on mean filter (Averaging), wiener filter (linear filter), median filter, adaptive filter and order statistics filter (non linear filters) applying on different types of medical images of lung including X-ray, CT, PET-CT scan.

Classification of Filters

Linear and Non-Linear Filters

Different types of filters available which are categorized as linear and non-linear.

1. Linear filter

(i) Average Filter

It is the one of the simple and easy to implement method for smoothing of images. In mean (average) filtering, each pixel value is replaced or substituted with the mean value of its neighbors, including itself in an image.

An example of average filtering is a single 3*3 kernel is shown in the figure below.

Unfiltered values

40	80	50
90	10	25
50	80	60

$$\begin{aligned} \text{Mean or average} &= 40+80+50+90+10+25+50+80+60 \\ &= 53.88 \end{aligned}$$

Filtered values

-	-	-
-	54	-

-	-	-
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Center value 10 is replaced by mean of all values (54).

(ii) Adaptive Filter

The Wiener filtering accomplishes best possible tradeoff between noise smoothing and inverse filtering. To remove the white noise and inverts the blurring all together wiener filter is very useful. Wiener filter approximates the variance and local mean in the region of each pixel. Wiener2 function performs smoothing depends on the variance [2], if it is large; smoothing is little else it is more.

(iii) Median Filter

Median filter is the nonlinear filter in which no new idealistic value is produced. When median of all pixels the window is calculated, center value of the kernel is replaced to determine the output pixel value which is the original pixel value [4].

Median Filter is the most accepted and valuable of the different types of filters and is commonly used for enhancement. From the ordered set of values, it selects the center pixel value inside the $p \times q$ neighbourhood in the region of the reference pixel. In particular, compared to the smoothing filters, median filters offer the following advantages:

- No reduction in contrast across steps
- It does not shift boundaries
- It smoothens additive white noise and effective in removing impulses.

It replaces the center value in the kernel with calculating median of all pixels around in the window. Median filtering is therefore better able to remove this outlier as it has advantage of keeping the sharpness of the image [7]. An example of such filtering of single 3×3 kernel is shown below:

Unfiltered values

40	80	50
90	10	25
50	80	60

$$\begin{aligned} \text{Median} &= 10, 25, 40, 50, 50, 60, 80, 90 \\ &= 50 \end{aligned}$$

Filtered values

-	-	-
-	50	-
-	-	-

Center value 10 is replaced by 50 (median of all values).

(iv) Alpha-Trimmed Filter

Alpha-trimmed filter is a new combination of averaging and order statistics in which an average of the pixel values nearby to the median of all pixels. The substantiation behind this filter is to allow its user to control its behavior by specifying the parameter [7].

(v) 2-D Order Statics Filter

Arrange all elements in the sorted order. In domain, orderth element replaces each element using function `ordfilt2` particularly by the nonzero elements. Domain is a matrix of only 0's and 1's; where for the filtering operation, the 1's characterize the neighborhood.

For instance, `x = ordfilt2(I,1,ones(3,3))` performs a 3-by-3 minimum filter; `x = ordfilt2(I,5,ones(3,3))` performs a 3-by-3 median filter; and `x = ordfilt2(I, 9, ones(3,3))` performs a 3-by-3 maximum filter;

Higher performance with large domain matrices can be achieved by using `I` in format of an integer data and matrices including non zero-valued elements.

(vi) Peak Signal-to-Noise Ratio (PSNR)

The peak signal-to-noise ratio is used to calculate the PSNR between two images which are articulated in decibels. This error metric works as a quality measurement tool between the original and the reconstructed image. As the PSNR elevates the quality of the compressed image becomes superior. The peak error is represented by PSNR. [3, 7]

(vii) Mean Square Error (MSE)

It is another error metric which compare the quality of image compression. The lower MSE value means the lower error. The cumulative squared error is measured between the original and compressed image and is represented by MSE [5].

METHODOLOGY

After selecting the image for input from the database, process it with different types of filters. The filters in this study used are mean (Average) filter, wiener filter which are linear filter and non linear filters like median filter, alpha-trimmed filter, and order statics filter. By calculating the MSE and PSNR values for each filter, accuracy is measured. Choose the filter of lower MSE and higher PSNR values.

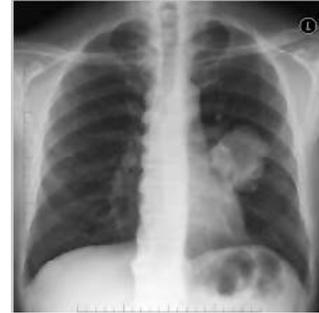
X - Ray Image of Lung



Original Gray Scale Image



Mean (Average) Filtered Image
(Linear Filter)



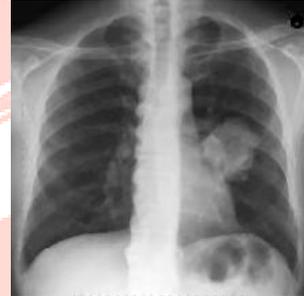
Wiener Filtered Image



Median Filtered Image



Alpha-Trimmed Filtered Image
(Non - Linear Filters)



Order Statics Filtered Image

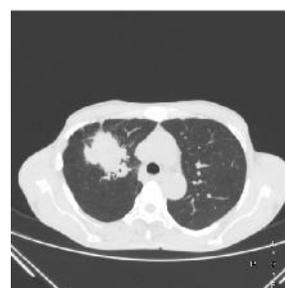
CT image of lung



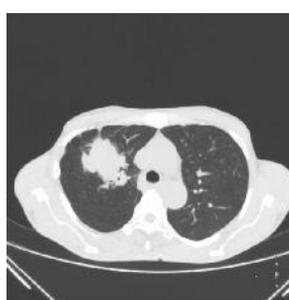
Original Gray Scale Image



Mean (Average) Filtered Image



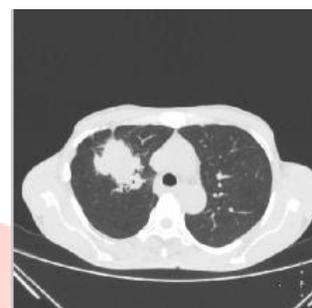
Wiener Filtered Image (Linear Filter)



Median Filtered Image



Alpha-Trimmed Filtered Image (Non - Linear Filters)



Order Statics Filtered Image

Comparison of Various Types of Filters on X –ray Images

Filters	PSNR	MSE
Mean (Average) Filter	10.16	6323.06
Adaptive Filter	43.15	3.18
Median Filter	40.06	6.47
Alpha-trimmed Filter	62.69	0.04
2-D Order statics Filter	40.06	6.47

Comparison of Various Types of Filters on CT Images

Filters	PSNR	MSE
Mean (Average) Filter	10.39	5996.33
Adaptive Filter	48.73	0.88
Median Filter	41.27	4.89
Alpha-trimmed Filter	62.89	0.03
2-D Order statics Filter	41.27	4.89

Table shows the comparison between the original image and filtered image when filtering models were applied for the removal of noise in these medical images in terms of MSE and PSNR. MSE and PSNR of alpha – trimmed filter when compared to other filter shows better results.

Conclusion

An assortment of linear and non-linear filters has been applied to analyze the X-ray and CT scan images to remove the unwanted artifacts. Removing the noise from the image is necessary to get better enhanced image for further progressions. To achieve the goal, the best filter technique has been selected by comparing the obtained results anchored in the performance in terms of MSE and PSNR values. Among all, alpha – trimmed filter performs well having lower MSE values but higher PSNR. Whereas median filter not only smoothens additive white noise but also maintains the contrast across steps.

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