Journal of Data Acquisition and Processing
ISSN: 1004-9037
https://sjcjycl.cn/
DOI: 10.5281/zenodo.7922948

ANALYSIS AND DENOISING MEDICAL LUNGS CT-SCAN IMAGES USING VARIOUS PREPROCESSING FILTERING TECHNIQUES

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Abstract— High-ranking noise components are problematic for medical imaging. Medical pictures can be obtained in many ways, including ultrasound, computed tomography, X-ray, and magnetic resonance imaging (MRI). When these processes occur, noise is introduced, lowering the image quality and hampering image interpretation. Images may be cleaned of noise or distortion while keeping their original quality using denoising algorithms. This research investigates the Mean, Median, Gaussian, Canny edge Detection, Wiener, Bilateral, and Laplacian filters on noisy pictures. Random noise and Gaussian noise may both be seen in the image. The Mean Squared Error (MSE), PSNR, and RMS are used to compare the results.

Keywords—COVID-19, X-ray, RTPCR, AI, CNN, VGG19.

Introduction

WImage denoising methods' primary goal is eliminating sounds without affecting the valuable information. There are several denoising techniques available. The formulas which are currently well-known also amplify picture noise. This presents several challenges for the rest of the procedure. Image denoising is a digital picture processing technique that removes noise from images to prevent image corruption. When it is being acquired or sent while maintaining its quality. The most used method for diagnosis in the medical industry is medical imagery from MRI, CT, and X-ray scans. Both random noise and Gaussian noise frequently have an impact on these photographs. Noise not only degrades the clarity of the image but also makes low-contrast items less visible. In medical imaging applications, noise reduction is crucial for enhancing and recovering small features that may have been lost in the data. The noise corruption in the images commonly hinders medical diagnostics based on them. Standard image processing approaches have been used to denoise MR pictures in response to the issue of image denoising, which has attracted a lot of attention. [1].

During the denoising process, relevant features in the image must not be significantly degraded. Edges are a critical component in medical photography, so edge protection must be balanced with noise reduction. Because they provide high localization quality in both space and frequency, Wiener Filter is often used in applications such as image denoising and enhancement. Wiener Filter is better at reconstructing sharp singularities than lines or edges because they do not isolate the smoothness of the edges. The Canny Edge Detection Filter corrects these errors.

Literature Survey

Peck H. S. Zadeh and colleagues [1] are the ones who are representing us. The credibility problem has gained a lot of attention due to the application of standard image processing technologies derived from conventional image processing to improve the picture quality of MR images.

Sezal Khera et al. [2], To obtain meaningful data for diagnostic purposes in its native form, modifications are necessary. The most recent and effective picture-denoising method is DWT (Discrete Wavelet Transform).

Tulasi Gayatri Devi et al. [3] present the approach for preprocessing. During the preprocessing phase of cell classification, the precision of the Wiener and Median filters is evaluated. Peak Signal Noise Ratio (PSNR) was built and analyzed for the Wiener and Median filters to improve picture classification in the future.

Anjali W. Pise [4] compare wavelets, adaptive filters, LPF Butterworth filters, Notch filters, and LPF Butterworth filters on sleep and epileptic EEG data.

Ashutosh Dehuri et al. [5] present the filtering methods, including median filtering, bilateral filtering, and a filtering technique based on transforms: the discrete cosine transforms (DCT). The goal is to assess each filter type's appropriateness for picture denoising.

Sugandha Agarwal et al. [6] compare and thoroughly examine the performance of nonlinear filtering algorithms to produce superior medical images from distorted images using various performance criteria, including PSNR, MSE, SNR, and MAE.

Sezal Khera et al. [7] present a study on medical picture denoising using Wavelet Transform and different filters. This study reviews several denoising algorithms, including Wavelet transform and various filters.

The novel image-denoising technique described by Manyu and Sheng Zheng [8] is based on the Gaussian Filter. The denoising technique in this paper is based on the NL means and the Gaussian filters; however, it varies significantly from both. Overall, the results of the experiments show that this method works better than the Gaussian and the NL-means filters. It is less likely than the Gaussian filter to produce fuzzy edges and less likely than the NL-means filter to keep a great structure.

Medical picture denoising was provided by Arin H. Hamad, Hozheen O. Muhamad, and Sardar P. Yaba [9], utilizing a few filters. Different filters were employed to reduce noise, including average, gaussian, log, median, and wiener filters. This study demonstrated that the Gaussian filter might be used to reduce noise in medical photographs.

Weaver [10] et al. suggested a straightforward wavelet-based noise reduction method. The fundamental fault of this filtering technique was the exclusion of any little structures comparable in size to the noise.

Anja Borsdorf and colleagues[11] demonstrated wavelet-based noise reduction in CT images. They did this by utilizing correlation analysis. Reconstructing from two separate projection subsets can result in the production of two CT images that are geographically similar. Most CT scanners may produce the two pictures by first sorting the collection of projections into those with even and those with odd-numbered projections. The photos displayed similar information, yet the amount of visual clutter varies significantly from image to image.

When a particular signal-to-noise ratio is met, it is possible to extract information from background noise by analyzing the connections between the wavelet representations of the input photos. V Nag Prudhvi Raj [12] proposed removing noise from medical data by employing a dual-tree complicated wavelet processing. Image decomposition and noise reduction were accomplished with a dual-tree complicated wavelet transform. During the contraction stage, the effectiveness of the two-dimensional tree complex wavelet transform for denoising medical images was evaluated by employing semi-soft and stein thresholding operators in addition to the typical soft and complicated adaptive threshold operators. This was done to determine which thresholding operators were most effective. This was done to expand upon the soft and complicated adaptive threshold operators. The results showed that the DTCWT-denoised picture had less redundancy than the Undecimated Wavelet Transform image and a better balance of smoothness and accuracy than the DWT (UDWT).

J. Mohan, V. Krishnaveni, and Yanhui Guo[13] present an overview of magnetic resonance image denoising approaches. This research summarizes different methods and introduces magnetic resonance imaging (MRI) and noise characteristics in MRI. This study divides popular techniques into several subcategories. The advantages and disadvantages of the denoising process are also discussed.

Denoising and resolution augmentation are two strategies presented by Rajeshwari S. and Sharmila T. Sree [14] to improve picture quality. The central themes of such a paper are Using a discrete wavelet transform (DWT) method, average, median, and Wiener filtering for picture denoise based on interpolation.

Wavelet 2D denoising and reduction of medical pictures were proven by Tanay Mondal and Dr. Mausumi Maitra[15]. The biological wavelet is applied at level 3 after loading the picture. The amount of soft threshold is then chosen to reduce the noise in the image.

Indulekha N. R. and M. Sasikumar[17] employed a three-dimensional discrete wavelet transform and a bilateral filter to produce medical picture denoising. The picture is split into eight subbands in this work using 3D DWT, followed by thresholding and bilateral filtering techniques. Bilateral filtering filters the approximation coefficient derived by DWT, and wavelet thresholding is used for the detail coefficients. To denoise 3D medical imagery, a three-dimensional discrete wavelet transform is employed.

Wavelet transform-based denoising of medical pictures was given by Taruna Grover [18]. This study showed that the sym4 wavelet outperformed the other two wavelets in terms of effectiveness at removing Gaussian noise with varying variances from medical photographs. The Curvelet Transform was first proposed as an image-denoising algorithm by Jean-Luc Stark et al. in 2002 [19].

IMAGE PREPROCESSING USING DIFFERENT FILTERS

In this section, the different filters for image processing are presented.

Mean Filter

The local average of the pixel intensities at each place is calculated using a low-pass filter known as the Average filter, also known as the Mean Filter in some contexts. A Mean Filter's impulse response may take any of the following shapes.

$$\begin{matrix} \frac{1}{9} & \frac{1}{9} & \frac{1}{9} \\ \frac{1}{9} & \frac{1}{9} & \frac{1}{9} \\ \frac{1}{9} & \frac{1}{9} & \frac{1}{9} \end{matrix} \quad (1)$$

The Mean Filter Impulse Response is applied to pictures to reduce the amount of noise in them. Since the Mean Filter takes an average across its neighborhood, it will suppress any white noise that originates from zero means, which will reduce noise if the image contains any white Gaussian noise.

Median Filter

Depending on the filter size, a 2D median filter will swap out all the pixels in a region with the median pixel intensity for that region. For reducing salt and pepper sounds, the Median Filter is practical. This noise often results from unexpected disruptions when taking pictures and manifests as black and white pixels in the photographs.

Gaussian Filter

A form of exponential regularizer known as a Gaussian filter chooses its weights based on the characteristics of a Gaussian function [3]. A valuable technique for minimizing distortion from a regularly distributed is the Gaussian smoothing filter. The zero-mean Gaussian function in one dimension is

$$G(x) = e\frac{x}{2\sigma^2}^2 \quad (2)$$

The two-dimensional discrete Gaussian function with zero means, utilized for image analysis, has a width determined by the Gaussian dispersion variable.

$$g[i,j] = e^{(i^2+j^2)2\sigma^2} \quad (3)$$

It is used as a smoothing filter [4].

Canny Edge Detector

An edge detection operator, the Canny edge detector, employs a multi-step process to identify different image edges. John F. Canny made it in 1986. Canny also further constructed a computational theory to understand edge detection's workings and applications. There are five stages to the Canny edge detection method.

Techniques like noise reduction, gradient computing, non-maximum suppression, and double threshold are examples. Hysteresis is employed in the tracking of edges by option e.

Noise reduction using Gaussian filter

The Canny edge detection algorithm uses a Gaussian filter to remove image noise. This is because sudden intensity changes by the edge detector are likely due to edges, and therefore the kernel should be normalized before being applied as a convolutional layer. This tutorial will use a kernel size of 5x5 and a sigma value of 1.4. The Gaussian filter will minimize the impact of blur and noise in an image. The equation for this kernel is:

$$G\sigma = \frac{1}{2\pi\sigma^2 \frac{e^{(x^2+y^2)}}{2\sigma^2}} \quad (4)$$

Gradient Calculation

Derivative computations are done concerning the x and y axes to create a smoother picture; Sobel-Feldman kernels can be used for this (convolution with image).

$$K_x = \begin{pmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{pmatrix}, K_y = \begin{pmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{pmatrix} \quad (5)$$

The gradient's magnitude and angle can be processed further once these kernels have been applied. By carrying out this procedure, the magnitude and angle may be determined.

$$|G| = \sqrt{+I_x^2 + I_y^2}$$
$$\theta(x,y) = arctan\frac{I_X}{I_y} \quad (6)$$

Non-Maximum Suppression

Finding two nearby pixels in the positive and negative gradient directions allows this step to reduce the number of duplicate pixels around the edges. This step assumes that each neighbor occupies an angle of pi/4. Nothing happens if the magnitude of the current pixel is smaller than any of these, and it is reset to 0 in all other circumstances.

Double Thresholding

The gradient magnitude comparison process works in two stages. In the first stage, gradients are compared with lower and higher threshold values. Any gradients that fall below the lower threshold value are suppressed, while any that exceed the higher threshold value are marked as solid edges and included in the final edge map. All other gradients remain unmarked and will be considered for further processing in the next step.

Edge Tracking by Hysteresis.

If a pixel on the edge map has a weak gradient, it will be connected to a strong gradient pixel nearby. This means that pixel W with a weaker gradation will be marked as an "edge" and included in the final edge map, depending on its location.

The gradient map of a pixel should be connected to the pixels around it by a chain of weak links. In other words, there should be an 8-pixel radius surrounding the considered pixel filled with weak connections. We will create and implement an algorithm that considers each pixel only once to find all the connected components of the gradient map. Afterward, you can choose which pixels will make up the final edge map.

Laplacian Filter

Laplacian of an image is a mathematical function that detects the areas of rapid changes in intensity. This technique can be used for edge detection and thus can be helpful in images such as photographs or scans. The Laplacian of an image at (x,y) is calculated according to the following equation:

$$L(x,y) = \frac{\partial^2 I}{\partial x^2} + \frac{\partial^2 I}{\partial y^2} \quad (7)$$

Laplacian Discrete Approximation: To approximate the Laplacian at a specific pixel, its weighted mean value is determined by analyzing specific nearby pixels. Fig. 1 shows two such kernels, which depict different methods for calculating this average.

0	-1	0
-1	4	-1
0	-1	0

(a)

-1	-1	-1
-1	8	-1
-1	-1	-1

(b)

Two kernels were used to approximate the Laplacian (a) Laplacian operator (b) Laplacian operator (including diagonal)

The Laplacian filter is a standard tool used to remove speckle noise and detect the edges of an image. This can be done using a Gaussian filter to reduce overall noise, then applying the Laplacian function from OpenCV to find the Laplacian value.

Wiener filter

The MSE-optimal solution is the Wiener, stationary linear filter, for the image noise and blur parameters. The Wiener filter is calculated using a method that requires knowledge of the second-order stationarity of the signal and noise processes (in a random sense). Spectral images may be estimated with DFT. The Wiener filter is defined by the spectra obtained in this manner:

$$\hat{S}(u,v) = G(u,v)X(u,v) \tag{8}$$

$G(u,v)$ = Fourier transform of the Point spread function (PSF)

$P_S(u,v)$ = Power spectrum of the signal process, obtained by taking the Fourier transform of the signal autocorrelation

$P_\eta(u,v)$ = Power spectrum of the noise process obtained by taking the Fourier transform of the noise autocorrelation

The Wiener filter is

$$\mathrm{G(u,v)} = \frac{\mathrm{H*(u,v)P_S(u,v)}}{\mathrm{|H(u,v)|^2P_S(u,v)+p_\eta(u,v)}} \tag{9}$$

By dividing via, it becomes simpler to describe its behavior:

$$\mathrm{G(u,v)} = \frac{\mathrm{H*(u,v)P_S(u,v)}}{\mathrm{|H(u,v)|^2+\frac{p_\eta(u,v)}{P_S(u,v)}}} \tag{10}$$

One interpretation of this statement is the opposite of the "signal-to-noise ratio." The Wiener filter becomes effective when the signal is relatively strong compared to the noise $\mathrm{H^{-1}(u,v)}$ – the PSF's inverse filter if there is little to no signal, $\frac{\mathrm{p}_\eta}{\mathrm{P_S}} \longrightarrow \infty$ and $G(u,v) \longrightarrow 0$.

The Wiener filter may be written as follows when there is additive white noise and no blur.

$$\mathrm{G(u,v)} = \frac{\mathrm{P_S(u,v)}}{P_S\mathrm{(u,v)}+\sigma_\eta^2} \tag{11}$$

Where σ is the noise variance

Filters Categorization Method:

One of the standard processes in image processing is de-noising. Getting precise data from degraded images is the primary goal of image processing. Filtering is changing an image's pixels based on nearby pixels. The image is improved with the use of filters. Filters reduce noise, enhance the image, and identify known examples. Filtering has been divided into many types.

I. METHODOLOGY

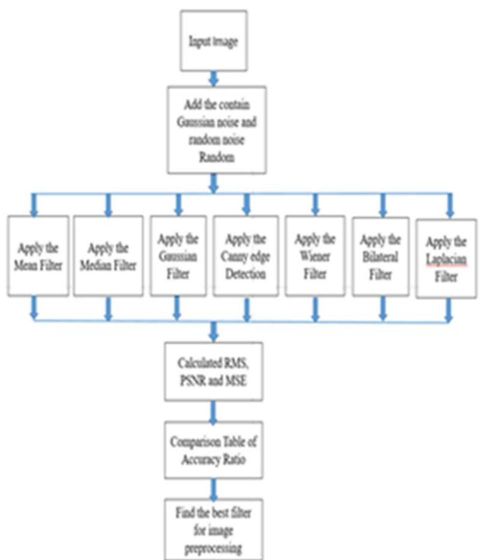
This investigation on several image denoising methods, including Mean, Median, Gaussian, Canny edge Detection, Wiener, Bilateral, and Laplacian filters, is presented in this publication. The Gaussian filter often blurs images, so the Wiener Filter removes noise without compromising signal characteristics. However, the Wiener Filter only approximates the horizontal, vertical, and diagonal coefficients, while the Canny edge Detection Filter delivers more directional coefficients and better edge and curve features.

The algorithm used in this study involves the following steps:

- Obtaining input images from the user
- Checking image size
- Resizing images if necessary
- Converting images to grayscale
- Applying noise (Gaussian or random)
- Performing image denoising using various filters
- Analyzing various parameters
- Displaying the input and output images

Comparing the results of the different filters

Flow chart for the proposed work



Flow chart for implementation of different filters

PERFORMANCE EVALUATION PARAMETERS

MSE, RMS, and PSNR are the most used full-reference quality measurements. The following subsections provide the meanings of various measurements

Mean Square Error (MSE):

The most popular method for evaluating the quality of images based on error sensitivity is MSE. It is calculated by averaging the squared intensity contrasts between each pixel of a reference picture and a warped image:

$$MSE = \frac{1}{MN} \sum_{i=1}^{M} \sum_{j=1}^{N} (xij - yij)^2 \qquad (12)$$

Where xij and yij are the reference image x's and distorted image y's image grey values, respectively, the dimensions of the photos are M and N.

Peak Signal-To-Noise Ratio (PSNR):

The most popular method for evaluating the quality of lossy compressed pictures is the PSNR. When warped, the PSNR is the ratio of an image's maximum power to its noise power. Because signal strengths typically span a broad dynamic range, it is represented in the logarithmic domain. Its equation is provided by

$$PSNR = 10\, log_{10} \frac{MAX^2}{MSE} \qquad (13)$$

Image quality factor based on RMS contrast:

Contrast is the fundamental perceptual characteristic of an image and the indicator of the sensitivity of the human visual system. It plays a big part in how computer displays are processed visually. Most of the work to date discusses how to evaluate image quality under various contrast and illumination settings. This study concentrates on rms (mean root square) contrast-based quality assessment to produce a meaningful and effective representation.

The standard deviation of brightness and the rms contrast measure is equal [3, 4, 20]. Thus, the following equations may be used to represent the RMS contrast of the pictures f(x, y) and g(x, y):

$$f_{rms=} \left[\frac{1}{xy} \sum_{x=0}^{x-1} \sum_{y=0}^{y-1} \{f(x,y) - \mu_f\}^2\right]^{\frac{1}{2}} \qquad (14)$$

$$g_{rms=} \left[\frac{1}{xy} \sum_{x=0}^{x-1} \sum_{y=0}^{y-1} \{g(x,y) - \mu_g\}^2\right]^{\frac{1}{2}} \qquad (15)$$

Result and Discussion

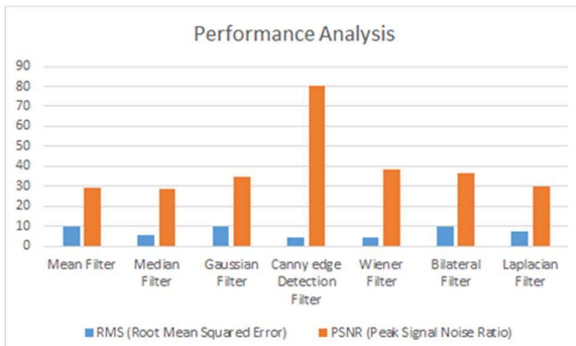
This paper presents the pre-processing approach for image enhancement using different Filtering processes with analysis. Table I represents the comparative analysis of the different filtering algorithms regarding RMS and PSNR.

Table I: Comparative analysis of different filtering algorithms

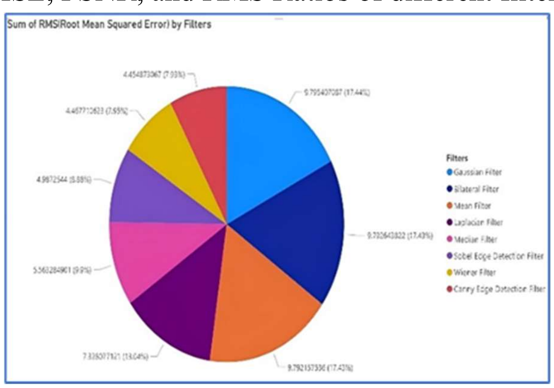
Sr. No.	Filters (Filtering Process)	RMS (Root Mean Squared Error)	PSNR (Peak Signal Noise Ratio)
1)	Mean Filter	9.792	29.220
2)	Median Filter	5.563	28.772

3)	Gaussian Filter	9.795	34.746
4)	Canny Edge Detection Filter	4.454	80.073
5)	Wiener Filter	4.467	38.117
6)	Bilateral Filter	9.792	36.636
7)	Laplacian Filter	7.328	29.627

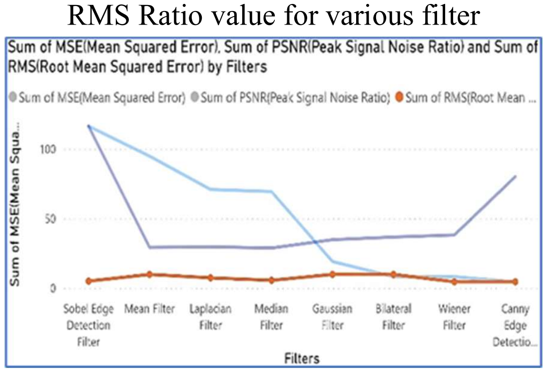
As shown in Table. One defined the full-reference quality metrics, proving the canny edge detection filter is better than Mean Filter, Median Filter, Gaussian Filter, Canny edge Detection Filter, Wiener Filter, Bilateral Filter, and Laplacian Filter. Where RMS, PSNR, and MSE values are 4.45,80.07and 4.45.



MSE, PSNR, and RMS Ratios of different filters



RMS Ratio value for various filter



Analysis of Different Filters

Conclusion

We have reviewed the various picture-denoising approaches in this research work. There were some scientific papers discussed. All concentrate on various facets & methods of image denoising. Both random and Gaussian noise can be found in medical imaging. The following filters were used in this study: Mean, Median, Gaussian, Canny edge Detection, Wiener, Bilateral, and Laplacian filters. A picture is primarily blurred by Gaussian filtering. To remove the noise without changing the properties of the signal, the Wiener Filter is used. The Wiener filter provides only approximate horizontal, vertical, and diagonal coefficients. The Canny edge detection filter offers a higher directional coefficient and superior edges and curve features than the Wiener Filter. Future work will denoise medical images with various wavelets to eliminate Rician noise, look, and toxins. We can also combine the Wiener and Canny edge detection filters to achieve better results. We tested a variety of image processing filters, calculated their RMS, PSNR, and MSE values, and determined their various ratios before concluding that the Canny edge detection filter and Weiner filters are the best options. These two image-processing filters excelled in image-preprocessing techniques and were found to be the best available.

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