

Comparative Analysis of COVID-19 Images through different Filtering Techniques using PSNR, MSE and SSIM

Ms. Urvashi B. Deshmukh¹ and Dr. Prapti D. Deshmukh²

¹⁻²Dr. G. Y. Pathrikar college of Computer Science and IT, MGM University, Chhatrapati Sambhaji Nagar, India
Email: urvashi.deshmukh17@gmail.com, prapti.research1@gmail.com

Abstract— Lung diseases are a significant global health concern, and early detection is imperative due to their contagious nature.

Integrating computer-aided detection technology with im-aging techniques can significantly enhance diagnostic accuracy.

Preprocessing techniques are pivotal for refining image quality.

Research has been conducted to identify the most suitable preprocessing filters for COVID-19 images obtained from hospitals. Evaluation techniques such as Peak Signal-To-Noise Ratio (PSNR), Structured Similarity Index Method (SSIM), and Mean Square Error (MSE) are utilized to assess image quality.

This study aims to determine the optimal techniques for enhancing image quality and improving diagnostic precision on private datasets. In conclusion, 62 images exhibited superior results with the bilateral filter, while the remaining 41 images demonstrated optimal outcomes with the Gaussian filter when analyzing images collected from the hospital.

Index Terms— MSE, PSNR, SSIM, Mean Filter, Gaussian Filter, Bilateral filter Laplacian Filter, Median Filter, image Preprocessing.

I. INTRODUCTION

Lung diseases represent one of the most prevalent medical situations globally, affecting millions. These conditions encompass a range of issues that impede the lungs' ability to function correctly.

Image data preprocessing has a vital role in enhancing accuracy & reliability of subsequent analyses. Study conducts a comprehensive comparison of various filtering techniques applied to private dataset of COVID-19, which have been meticulously collected from MGM Hospital, Chhatrapati Sambhaji Na-gar.

By evaluating the effectiveness of these filtering methods, we aim to determine the most suitable techniques for optimizing image quality and facilitating more precise diagnostic outcomes, this study focus on filters for preprocessing.

After collecting the data, we meticulously reviewed it to identify images with the most significantly affected areas. where different filters has been applied such as Mean Filter, Median Filter, Gaussian Filter, Bilateral filter Laplacian Filter. From this process, we selected lung CT images that exhibited the highest degree of abnormality for analysis.

The resulting images apply the different filters and it is evaluated with PSNR, SSIM and MSE measures.

II. RELATED WORK

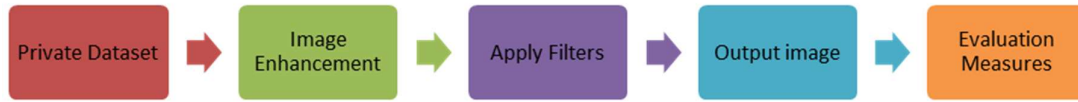
In this research, Srivastava, Hari et al. focused on the processing and detection of tiny moving subjects which are taken for study and occupies small pixels, texture less & shape info. It has low signal-to-noise plus clutter ratio-SCNR. Various pre-processing algorithms were employed to improve SCNR, including spatial, temporal, and spatiotemporal methods. The study targets to seamlessly incorporate the background into the original image without compromising the visibility of the target signal. A hybrid morphological filter provides a significant increase in SCNR was proposed for the detection of slight or point targets [2]. In this study, Arin H. Hamad et al. examined various types of noise, including Poisson, speckle, and Gaussian, and applied de-noising techniques to mitigate these disturbances in images. They employed several filters, such as the Average filter, Gaussian filter, Log filter, Median filter, and Wiener filter, to reduce noise. The evaluation aimed to determine the most effective filter on medical images of cells and breast tissues. Image quality was assessed using metrics like PSNR- Peak Signal-To-Noise Ratio, SNR-Signal-To-Noise Ratio and MSE-Mean Squared Error. The findings suggest that the Gaussian filter is particularly well-suited for effectively reducing noise in medical images [3]. A. Arshaghi et al. conducted a study compares different denoising methods for medical images, including non-local means - NLM, wavelet transform, Deep Convolutional Neural Networks (Dn-CNN) and different filters such as the adaptive Wiener filter and median filter. The performance measures are evaluated using metrics like SSIM, PSNR and MSE [4]. Kumar A.& Sartaj Sodhi compared the effectiveness of the Median filter, Gaussian filter as well as De-noising Autoencoder for noise removal in an image. The final output of images was assessed using different metrics like processing time, SSIM, PSNR and NMSE. The results indicate - Median filter outperforms other techniques in terms of time efficiency and overall performance in certain scenarios [5]. N. Nawreen et al. present a two-layer reconstruction framework that effectively decomposes images into a smooth layer and a texture layer, thereby enhancing computed tomography (CT) images for improved lung cancer diagnosis. This framework employs a generative model that accepts low-resolution images as input, utilizes ImageNet for feature extraction, and generates content-based high-resolution images. Experimental findings substantiate the efficacy of the proposed algorithm, demonstrating significant improvements in mean average precision (mAP) and peak signal-to-noise ratio (PSNR) compared to existing methodologies.

[6] To address the challenges associated with excessive smoothness and blurring in reconstructed images, the authors implement this two-layer reconstruction framework, facilitating the separation of the image into distinct smooth and texture layers. This innovative technique yields clearer CT images for lung cancer diagnostics by achieving an optimal balance between detail preservation and smoothness. The framework employs a generative model that processes low-resolution input images while leveraging ImageNet as a feature extractor to derive high-resolution features for content-based image construction. The proposed method exhibits superior performance, as evidenced by higher mean average precision (mAP) and peak signal-to-noise ratio (PSNR) in comparison to conventional approaches.[7] This study introduces an innovative methodology for image denoising and edge detection, serving as preprocessing steps applicable to a variety of image types. The proposed technique first implements a Laplacian of Gaussian filtering approach for edge detection, subsequently followed by noise reduction utilizing Gaussian filtering. To validate its effectiveness, this method will be evaluated across nine distinct images, encompassing X-ray images, satellite imagery, articular imaging, industrial imaging, and general-purpose imaging. The performance of the edge detection technique will be assessed through various metrics, including Mean Squared Error (MSE), Root Mean Squared Error (RMSE), and Peak Signal-to-Noise Ratio (PSNR), in addition to execution time analysis.[9]

R. Rizal et al proposed research to determine the effect of changes in image quality after applying median filtering (MF), Wiener filtering (WF), HE, or hybrid methods on noisy images. Once the preprocessing is completed, Gaussian and salt-and-pepper noises with intensities of 20%, 50%, and 80% were applied to the images. Where HE, MF, WF, hybrid method 1 (HE and MF), and hybrid method 2 (HE and WF), are implemented. Image quality is measured using PSNR, MSE and SSIM. In result best method which enhance image quality of Gaussian and salt-and-pepper noisy images are Wiener filter and median filtering respectively. [10]

III. PROPOSED METHODOLOGY

In the proposed methodology collection of private dataset, enhancing a image, applying filters like mean, median, , Gaussian, Bilateral and Laplacian filter are applied where on resulting image evaluation measures (MSE,PSNR and SSIM) have been applied to determine the suitable techniques for optimizing image quality and facilitating more precise diagnostic outcomes.



A. Image Enhancement

Image enhancement operations primarily focus on sharpening Image features, like boundaries and edges while reducing Artefacts caused through contrast differences. For Proposed System, these operations are crucial for improving image quality and ensuring accurate analysis.

Resize Image: All the CT images were preprocessed for resizing to 512x512. It again preprocessed for cropping them to obtain specific dimension and position. This step ensures that the ROI is consistently aligned and standardized across all images, facilitating more accurate and reliable subsequent analysis.

RGB 2 GRAY: Then convert RGB image to grayscale i.e. three channel to single channel. For making it easier to work with grayscale images. Finally, we applied different filtering on the input images.

B. Filtering Techniques

Mean filter

A Mean filter is a smoothing filter that substitutes the brightness of a pixel with a mean brightness of a pixel and its neighbours. This operation effectively reduces noise and intensity variations, resulting in a smoother image.

Median filtering

Median filtering is employed for image smoothing. This nonlinear operation is more effective as compared to convolutional techniques for denoising while preserving edges. Zero-padding technique is applied by the filter to the edges for ensuring the median values not affected at boundaries.

Gaussian filter

The obtained grayscale image cannot be used directly as there might be some random variations in the intensities of the pixel values which can be termed as noise. These noises may be impulse noise, Gaussian noise, salt and pepper noise or any other.

Bilateral filters

A non-linear, noise-reducing smoothing filter is used to process images. This filter effectively reduces noise while maintaining the integrity of edges, ensuring that important details are preserved.

Laplacian filter

An edge detector is used to compute the second derivatives of an image, assessing the rate of change of the first derivatives. This method effectively highlights areas of rapid intensity change, thereby identifying edges within the image.

C. Evaluation Measures

The MSE and PSNR are used for comparing the image compression quality. The MSE signifies the cumulative squared error between the compressed and the original image. A lower MSE value indicates lower error. The Mean-Square Error and Peak Signal-To-Noise Ratio are metrics which are considered for comparing image compression quality. PSNR measures the peak error. The mean-squared error can be calculated using the equation-

$$MSE = \frac{\sum_{m,n} [I_1(m,n) - I_2(m,n)]^2}{M * N}$$

The equation shows M and N as rows and columns in the input images respectively.

Once MSE is calculated, the PSNR value will be calculated using the given following equation-

$$PSNR = 10 \log_{10} \left(\frac{R^2}{MSE} \right)$$

The SSIM, which is also a matrix, calculates the resemblance between two images based on the human visual system, offering an improvement over traditional metrics. The SSIM is defined by the following equation [4],

$$SSIM(x, y) = \frac{(2\mu_x\mu_y + c_1)(2\sigma_{xy} + c_2)}{(\mu_x^2 + \mu_y^2 + c_1)(\sigma_x^2 + \sigma_y^2 + c_2)}$$

Where:

x and y represent the two images being compared (histogram equalization image and the filtered image filtered).

μ_x and μ_y are the mean intensities of images x and y

σ_x^2 and σ_y^2 are the variances of images x and y .

σ_{xy} is the covariance between images x and y .

C_1 and C_2 are constants to avoid division by zero.

IV. RESULTS AND DISCUSSION

After applying filters on an image, we used methods to evaluate and access the Image quality parameter are Mean Squared Error, Peak Signal-To-Noise Ratio and Structural similarity index to find the finest filter appropriate for given dataset. High PSNR and SSIM index value indicate better quality to the original image where in MSE lower value indicate better quality to the original image. Among 103 images 62 images gives Higher SSIM, PSNR and lower MSE values indicated on bilateral filter where 41 images give Higher PSNR, SSIM & lower MSE values on Gaussian filter.

A. Figures and Tables

Filters were applied to Image IM-0002-0012.jpg, as shown in Figure 1 and Figure 2. After filtering, we used evaluation measures on the resulting image to determine which filter provided the best results. Where Table 1 presents the calculated PSNR, SSIM, and MSE metrics for the resulting image and Figure 3 shows outcomes on number of CT images using filters. Figure 1 displays the various filters on a CT image, including Mean, Median, Gaussian, Bilateral, and Laplacian filters.

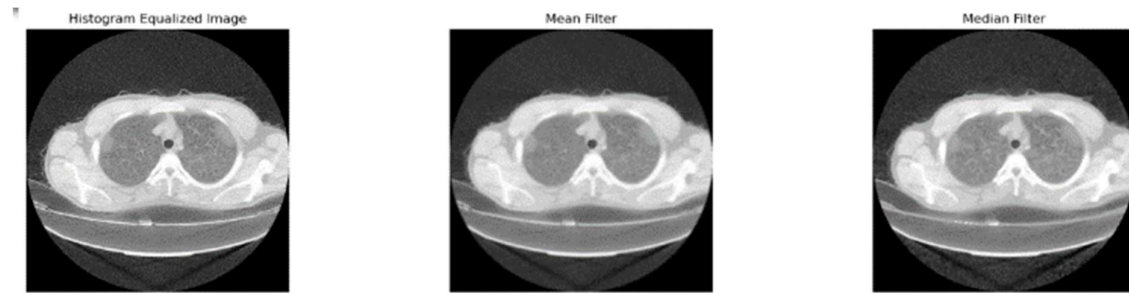


Fig. 1: Mean and Median filters applied on IM-0002-0012.jpg

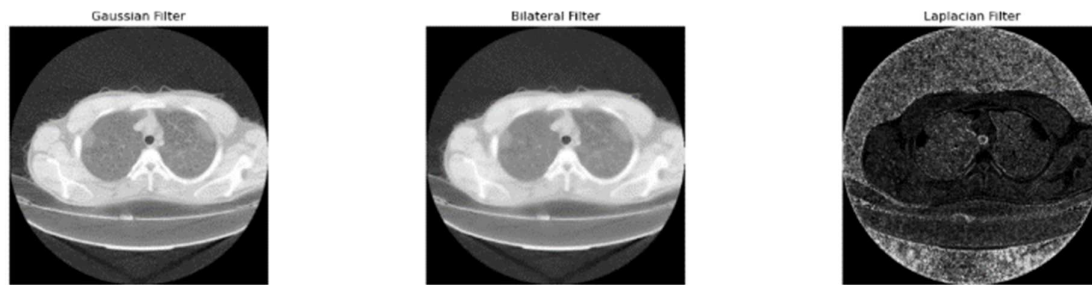


Fig. 2: Gaussian, Bilateral and Laplacian filters applied on IM-0002-0012.jpg

TABLE 1: PSNR, SSIM AND MSE VALUES OF FILTERING TECHNIQUES ON IM-0002-0012.JPG

Applied Filters	Evaluation Measures		
	PSNR	SSIM	MSE
Mean Filter	22.24	0.4797	388.19
Median Filter	22.24	0.4916	388.29
Gaussian Filter	23.57	0.6221	285.84
Bilateral Filter	23.86	0.5612	267.42
Laplacian Filter	6.69	0.1444	13937.86

Figure 3 displays the outcomes of computed tomography (CT) imaging where the application of Mean, Median, and Laplacian filters did not yield satisfactory results. These outcomes were evaluated using metrics such as Peak Signal-to-Noise Ratio (PSNR), Structural Similarity Index Measure (SSIM), and Mean Squared Error (MSE). In contrast, the Gaussian filter successfully produced results for 41 images, while the Bilateral filter demonstrated efficacy in 62 images.

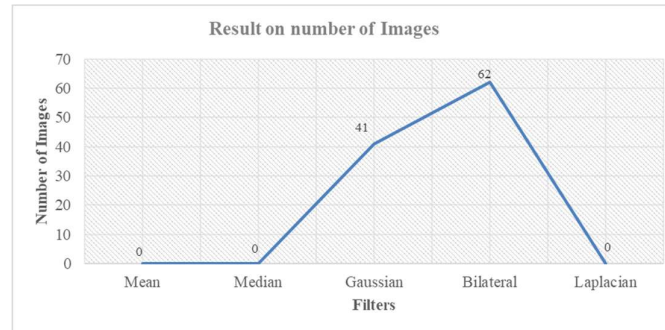


Fig. 2: Result on number of CT Images using Different Filters

V. CONCLUSIONS

This study only focus on Pre-processing of data, as Pre-processing is important step to clean raw data into, machine-readable data set which helps models to work effectively. It also eliminates problems such as missing values, outliers and other errors in the system. once the data is collected enhancing the data is second part where we have resized the data into 512 x 512 and converted the dataset from RGB2Gray after the enhancement we applied different filters on the dataset such as Mean Filter, Medi-an Filter, Gaussian Filter, Bilateral filter Laplacian Filter on 103 images and assessed their performance using MSE, PSNR, and SSIM metrics. High SSIM and PSNR values specify improved quality of image, while a lower MSE value signifies greater similarity to the original image. Among the 103 images, 62 achieved the best results with the bilateral filter, while the remaining 41 images showed optimal results with the Gaussian filter. Consequently, we conclude that both the bilateral and Gaussian filters provide the best results for our locally collected COVID-19 dataset.

FUTURE SCOPE

The Evaluation matrix used for image quality assessment (PSNR, SSIM and MSE) did not provide accu-rate output as desired. To improve better image quality assessment Still there is need for other tech-niques to be involve and also other image quality assessment metrics for digital image processing.

REFERENCES

- [1] N. S. Nadkarni and S. Borkar, "Detection of lung Cancer in CT Images Using Image Processing," 2019 3rd International Conference on Trends in electronics and Informatics (ICOEI), Tirunelveli, India, 2019, PP. 863-866, DOI: 10.1109/ICOEI.2019.8862577.
- [2] Srivastava, Hari & Kumar, V. & Verma, H.K. & Sundaram, S.S. (2009). Image Pre-Processing Algorithms for Detection of Small/Point Airborne Targets. Defence Science Journal. 59. 166-174. 10.14429/DSJ.59.1505.
- [3] Hamad, A.H., Muhamad, H.O., & Yaba, S.P. (2015). De-noising of medical images by using some filters.
- [4] Arshaghi, Ali & Ashourian, Mohsen & Ghabeli, Leila. (2020). Denoising Medical Images Using Machine Learning, Deep Learning Approaches: A Survey. Current Medical Imaging Formerly Current Medical Imaging Re-vIEWS. 16. 10.2174/1573405616666201118122908.
- [5] A. Kumar and S. S. Sodhi, "Comparative Analysis of Gaussian Filter, Median Filter and Denoise Autoenocod-er," 2020 7th International Conference on Computing for Sustainable Global Development (INDIACom), New Delhi, India, 2020, pp. 45-51, doi: 10.23919/INDIACom49435.2020.9083712.
- [6] N. Nawreen, U. Hany and T. Islam, "Lung Cancer Detection and Classification Using CT Scan Image Pro-cessing," 2021 International Conference on Automation, Control and Mechatronics for Industry 4.0 (ACMI), Rajshahi, Bangladesh, 2021, PP. 1-6, DOI: 10.1109/ACMI53878.2021.9528297.
- [7] S. Garud and S. Dhage, "Lung Cancer Detection Using CT Images and CNN Algorithm," 2021 International Conference on Advances in Computing, Communication, and Control (ICAC3), Mumbai, INDIA, 2021, PP. 1-6, DOI: 10.1109/ICAC353642.2021.9697158.

- [8] Raushan Kumar, Gunjan Sharma, Varun Sanduja "A Real Time Approach to Compare PSNR and MSE Value of Different Original Images and Noise (Salt and Pepper, Speckle, Gaussian) Added Images" International Journal of Latest Technology in Engineering, Management & Applied Science (IJLTEMAS) Volume VII, Issue I, January 2018 | ISSN 2278-2540
- [9] S. Mathur and S. Gupta, "An Enhanced Edge Detection Using Laplacian Gaussian Filtering Method from Different Denoising Images", Int J Intell Syst Appl Eng, vol. 12, no. 18s, pp. 313–323, Mar. 2024.
- [10] R. R. Isnanto, Y. E. Windarto and M. V. Mangkuratmaja, "Assessment on Image Quality Changes as a Result of Implementing Median Filtering, Wiener Filtering, Histogram Equalization, and Hybrid Methods on Noisy Images," 2020 7th International Conference on Information Technology, Computer, and Electrical Engineering (ICI-TACEE), Semarang, Indonesia, 2020, pp. 185-190, doi: 10.1109/ICITACEE50144.2020.9239153.
- [11] S. Khatri and H. Kasturiwale, "Quality assessment of Median filtering techniques for impulse noise removal from digital images," 2016 3rd International Conference on Advanced Computing and Communication Systems (ICACCS), Coimbatore, India, 2016, pp. 1-4, doi: 10.1109/ICACCS.2016.7586331.
- [12] R.C. Gonzalez, R.E. Woods, Digital Image Processing, 3rd edition. New Jersey: Prentice-Hall, 2008.