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Denoising Medical Images Using Filters

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***Abstract*— Images, since their invention, have proved extremely vital in a lot of processes that happen in our day- to-day life. The medicine industry is one of the most crucial lifelines, which makes use of images quite extensively. Information amassed from these can provide medical professionals an insight into problem at hand, and if gathered timely, can pave way for faster and more accurate diagnosis while providing appropriate treatments. Modifying the images also helps in detecting diseases beforehand. Images are very commonly affected by different types of noise due to external factors such as interference. A common way of noise removal i.e. denoising an image is using filters. This leads to better quality of images for more accurate information. Hence, enhancement, noise-removal and filtration of noisy images is a significant aspect of the process. The paper provides an understanding of various image denoising methods and reviews the results for the same.**

Keywords— Medical Image Processing; Image Processing; Image Filtering; Denoising

I. Introduction

Image Processing is a domain that revolves around performing operations on digital images. These operations can vary, from blurring an image to sharpening it. This domain has found its uses in many industries, and due to the advancements in technology over the years, support of such systems has become easier. The field of medicine has the potential to benefit from integrating such models. Image pre-processing, enhancement, and extraction are widely used to analyze specific data from a given image to detect any abnormalities or unusual occurrences. The images can then be used for detection, and subsequent treatment, of any possible harmful diseases in the human body. Medical Images are plagued by multiple issues during acquisition and the transmission phases; image distortion is a common phenomenon mainly due to the introduction of Noise in the image. Image denoising has become an important step in Medical Image Processing. Noise is defined as unwanted aspects/attributes of an image, i.e. unwanted data. Image denoising is performed using a variety of methods, all of which involve using some sort of image filters. Different filters have different effects on the image, depending on its weights. Since the operations that are performed are done so on a digital system, the images too must be digital in nature; the images provided are present in terms of pixels, and thus the mathematical operations that need to be performed on these also rely on pixels.

The images considered for testing are those that are used frequently in hospitals: Magnetic Resonance Images (MRI), Computed Tomography (CT) scan images, Ultrasound images, and X-Ray images. The effect that filters have on images varies according to the weight and the usage of the chosen filter. These filters differ in size, and can be as small as 3x3, or even as large as 20x20. The larger the filter, the stronger is the effect of the blur noticed after processing. [1], [2]

To draw a suitable conclusion, comparison between images need to be performed. Thus, there needs to be a common location where other similar images are stored. After one image is selected, it then goes through the different steps of Image processing and generates a result. The output thus yielded from these processes is highly accurate and does not need any complex manual steps to be performed by an individual.

The rest of the paper is organized as follows: Section II discusses the various types of noises and section III discusses the various types of filters. The methods used by various researchers are discussed in Section IV. Section V discusses the inferences from the results.

II. Types of Noises

A. *Rician Noise*

Sometimes, fading in an image can occur, which is caused by the partial cancellation of a signal by itself. This phenomenon is known as Rician fading. This happens when the signal is travelling to a destination while taking multiple different paths, leading to interference. [3]

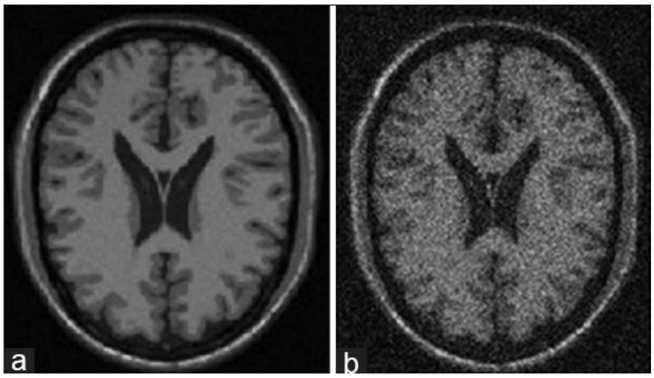

Fig. 1. Rician Noise

B. Gaussian Noise

Gaussian Noise is a type of statistical noise that has a probability density function (PDF) associated with it. This distribution is akin to that of the normal distribution. This is also known as Gaussian distribution; hence the name.

There is a special case that exists, known as White Gaussian noise [4], where the occurring values are not dependent on the distribution.

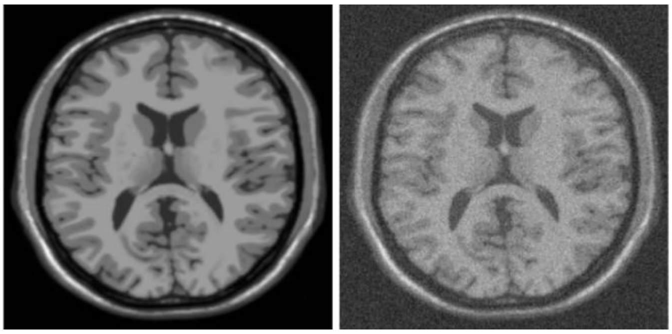

Fig. 2. Gaussian Noise

C. Salt and Pepper Noise

Salt & Pepper noise, one of the most commonly occurring types, appears in the form of random black and white spots in the image, which distorts the quality of image. This type of noise is easy to remove using Median filters. [5]

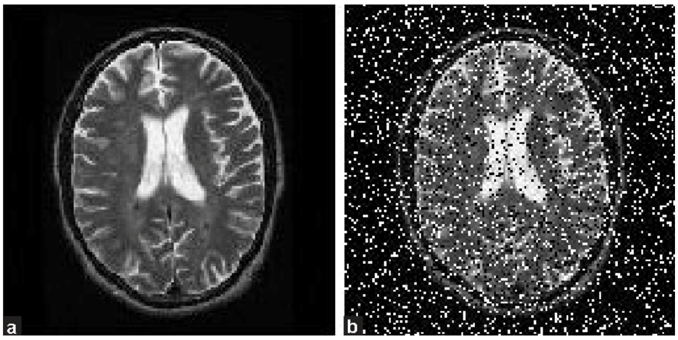

Fig. 3. Salt and Pepper Nosie

D. Speckle Noise

Speckle Noise is the kind of noise that results in granularities in the image. This is quite commonly observed in Medical imaging due to the presence of elementary scatterers. Speckle noise is termed as a multiplicative noise and is represented as the difference between 2 neighboring pixels. Speckle is a unique phenomenon; it cannot be filtered out using normal linear filters. [6] [7]

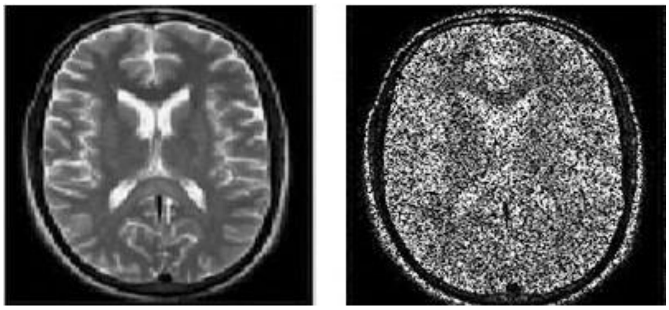

Fig. 4. Speckle Nosie

III. Types of Filters

A. Mean Filter

This type of filter works by decreasing the difference in intensity among two neighboring pixels. When an image is being considered for filtering, the pixel value that is to be changed is replaced with the mean (or average) value of its neighbors. Such a method helps in eliminating those values that do not belong in a range of the neighboring pixels.

B. Median Filter

Median filters help to eliminate noise in an image. They do a much better job at preserving the image details than mean filters. A median filter looks at the neighborhood of the pixel under consideration to determine the value of the pixel. The value of the pixel is replaced by the median of the pixels in the neighborhood being considered. A median filter is used with a fixed size window. Due to the nature of the filter, there is always a possibility of a perfectly fine pixel getting replaced by a corrupt/incorrect pixel. [8] [9]

C. Wiener Filter

A Wiener filter is used to calculate an estimate of an unknown image using a related image as an input and filtering the related image to arrive at an approximation of the original image i.e. Given an image containing noise and a related image, using a Wiener filter on the related image helps arrive at a likeness of the original image. [10]

D. Midpoint Filter

In this type of filter, the value of each pixel is replaced by taking the mean of the highest and lowest pixel value of a window size, which is done so with respect to the intensity present in the image.

IV. Proposed Works

A. Brain Tumoe Detection Using CNN

1) Data Set Collection: The images necessary for the model need to be collected before starting with the process. A. Sankari et. al gathered the Tumor oriented data sets from International Bariatric Surgery Registry (IBSR) and Brain Tumor Segmentation (BRATS) 2015 for the segmentation process. 50% of these data sets was used for Training, 30% for Testing, and 20% for Validation.

2) Pre-processing: The quality of segmentation is determined by the amount of noise present in the image. For the MRI input images, Bilateral filter was used to remove the noise present in the images. It also helped to preserve edges.

3) Image Enhancement and Feature Extraction: Histogram Equalization was used to enhance the images to make sure maximum amount of information is obtained. Next, the significant elements of the image were extracted and given to the classifier.

4) Classification by CNN: The Convolutional Neural Network (CNN) is constructed using three layers; convolutional layer, fully connected (FC) layer, and the pooling layer. The CNN got patches of information extracted from the MRI images and treated them as inputs. Local subsampling was then used to get features like edges and lines.

5) Validation: The results of the image after and before enhancements were observed, and is given as per the figure below [11]:

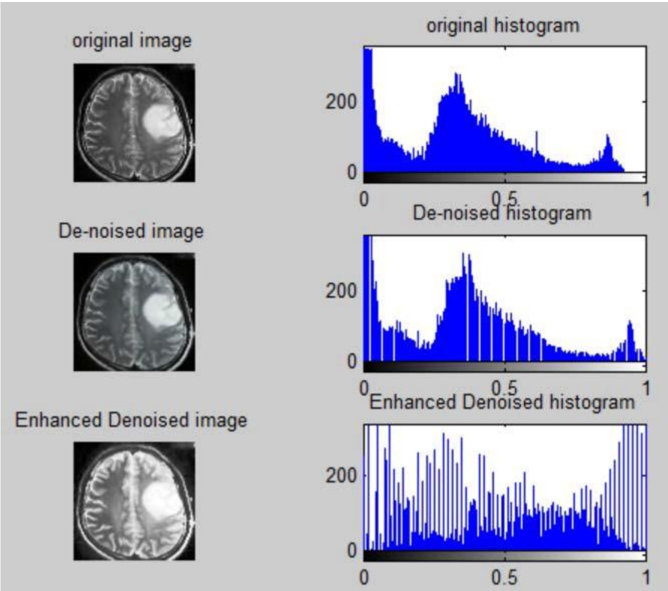

Fig. 5. Before and After Enhancement [11]

B. Lung Cancer Detection

1) Image Database: Pooja R. et. al gathered a collection of all the necessary CT scans that would be taken as input. Some images, which weren't already available in a readable format, were converted thus using conversion tools, specifically designed for this purpose.

2) Image Pre-processing: The input images were first smoothed, enhanced, and then image segmentation was performed. The smoothing of the image was done via a median filter. This particular method was chosen as, compared to other methods for the type of input images used, this did not result in the image getting blurry. In order to improve the visibility of the image, enhancement techniques had to be performed. This was done so by making use of a High Boost filter. This gave more focus to areas of high frequency.

3) Feature Extraction: This step was performed to determine the shape of the nodule (or tumor), and its size. The features that were extracted are the area, perimeter, and the eccentricity of the image. Area gave the total pixels occupied within the nodule, perimeter gave the total amount of pixels present at the boundary of the nodule, eccentricity helped to determine the shape of the tumor. If eccentricity is 1, the shape obtained is a circle.

4) Image Classification: To mine data, Support Vector Machine (SVM) was used to help analyse a pattern. It was preferred since it makes two sets of data from the same given set and accordingly categorizes the input. CNN, along with fuzzy logic, was used to classify the gathered data. The changes in the input and the enhanced images were observed [12]. The location, as well as the size of the nodule, could now be noticed. In this scenario, an accuracy of 94.12% was observed.

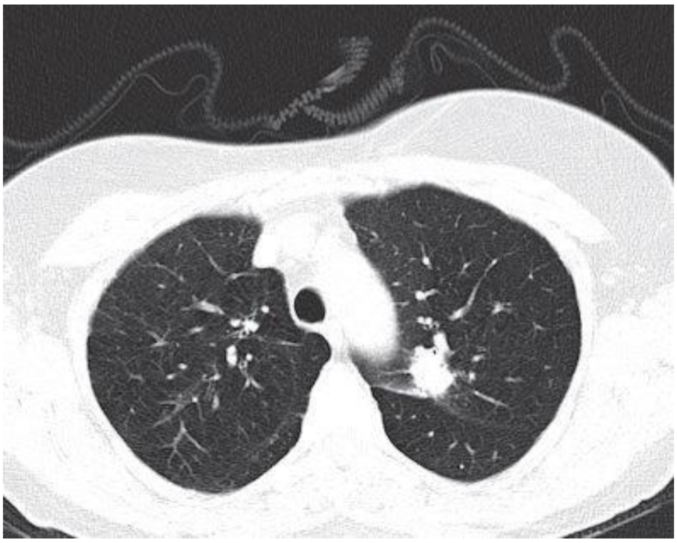

Fig. 6. Input Image [12]

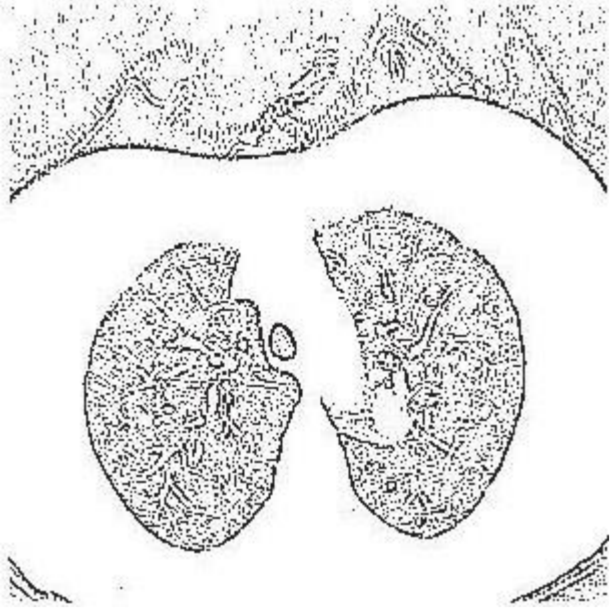

Fig. 7. Input Image [12]

C. Multi-direction Median Filter

The above-mentioned method was proposed by Xiaofeng Zhang et. al [13]. The method is based on three different concepts namely:

1) Local Direction Detection: This step forms a crucial part and thus follows specific constraints like it should be immune to noise, work in low contrast conditions and should be able to detect different directions.

2) Multi-direction Template: Various kinds of templates can be used for median filtering. Multi-direction template is the one being used in this method.

3) Multi-direction Median Denoising: The denoising method follows a number of steps:
In the first step the local direction is determined by taking the maximum direction value which is obtained by using various filters. In second step multi-direction median filtering is carried out corresponding to the direction given by the first step. In the final step denoising result of each pixel is determined. The method helps to determine direction for filtering in complex situations like low contrast condition.

D. Denoising using Spatial Filters and Wavelets

The following method combines the concepts of spatial filters and wavelets to reduce the noise present in an image. This method was proposed by Alberto Palacios Pawlovsky et. al.

The data required to test the method was collected from the Japanese Society of Radiology Technology.

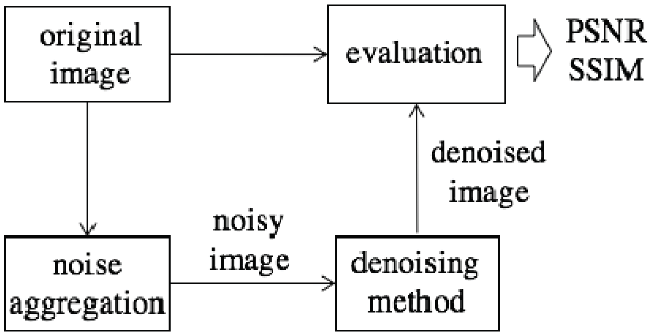

Fig. 8. The Process[14]

To differentiate between the proposed method and other methods, Gaussian noise was introduced in the test images. PSNR and Structural Similarity Index (SSIM) were used to determine the noise reduction capabilities of this method. It was found that approximate coefficients gave the best results. Therefore, the method first uses a Gaussian filter followed by approximate coefficients method to reduce image noise. The method is compared against the soft-threshold method [15], non-local mean filtering method [16] and denoising method [17]. The results show that the above-mentioned method shows a significant increase in PSNR compared to other methods mentioned.

E. Leukemia Detection

1) Image Classificaton: Thresholding is the most commonly used image segmentation method; it is used to create binary images from a given grayscale image. Otsu's thresholding method applies an iterative process containing all probable threshold values, thus computing the degree of spread for the pixel levels present at each side of the threshold. This classifies the pixels as either falling in the foreground or background. Image Classification aims to obtain the threshold value where the sum of foreground and background spreads is at its minimum. Image classification encompasses the following:

a) All conversions are done on input greyscale image.

b) After preprocessing, global threshold Otsu's method is applied on contrast enhanced blood cell images, taken as input.

c) To reduce noise, edges are preserved, and thedarkness of the nuclei (darkest part of the image) is increased using a 3x3 minimum filter.

d) The resultant image is of the leukemia influenced cells.

2) Feature Extraction: The entire process defines three characteristics of lymphocyte cells: *area*, *perimeter* and *circularity*. Shape of the nucleus is the prime factor for differentiation of observed blasts [18]. Feature extraction consists of:

a) The number of pixels of the nucleus of the WBC is counted.

b) Area: This is obtained after step 1.

c) Perimeter: This can be acquired by calculating the distance between each adjoining pair of pixels around the border of the region under focus.

d) Circularity: 4*Pi*Area/Perimeter

e) Eccentricity: This parameter is used to measure how much a shape of a nucleus deviates from being circular. Eccentricity is the ratio of the Major to the Minor axis. It's an essential feature since normal blood cells have been observed as being more circular than the blast.

After the previous steps are completed SVM is used for image classification.

F. Salt and Pepper Noise Removal

Shilpi Gupta et al. proposed a Salt and Pepper noise detection and image restoration algorithm for a given noisy image [19].

1) Noise Detection: Initially, the maximum (Smax) and minimum (Smin) pixel values are found and are assigned as corrupted pixels in the grayscale image. These values of noisy pixel have equal probabilities but are less correlated with each other. The less correlation implies that, the corrupted pixels have a probability of 'q' and uncorrupted pixels '1-q'. Binomial distribution is applied as it is the most suitable technique to find the mask size, since the performance of the filter depends on size of the mask based on the specified values construct the set containing all noisy pixels.

2) Restoration Method: The nearest neighbor matrix is used on the noisy image to obtain a noise-free image. Total weight of matrix is constructed, and average filter is applied on it. The MWAF is used to filter the noisy image. To quantify the amount of noise removed, two parameters are evaluated, i.e. Peak Signal to Noise Ratio (PSNR) and Mean Square Error (MSE). Here, PSNR is used to measure how much noise is removed from the image or can also be defined as how many pixels do not contain any type of noise. The deviation occurred in the output image from the original image in terms of noise in the process is deduced from MSE. MSE also signifies the total energy contained by each pixel.

V. CONCLUSION

The steps taken to enhance the image yielded noticeably clearer outputs at each instance. These phenomena were observed for different types, as well as levels of noise. The results noticed were positive irrespective of the type of medical images used. Thus, using filters for the enhancement of medical images proves to be advantageous for detection of various diseases present in the human body. Subsequently, this could help in the decision-making process with regards to various forms of available treatments.

References

[1] K. Funahashi, S. Hirano, T. Goto, T. Mori, and Y. Sano, "Super-resolution method and its application to medical image processing," in 2017 IEEE 6th Global Conference on Consumer Electronics (GCCE 2017), 2017.

[2] W. Rui and W. Guoyu, "Medical x-ray image enhancement method based on tv-homomorphic filter," in 2017 2nd International Conference on Image, Vision and Computing (ICIVC), 2017.

[3] "Rice distribution," 2018. [Online]. Available: https://en.wikipedia.org/wiki/Rice_distributions.

[4] Suhas. S and C. R. Venugopal, "MRI image preprocessing and noise removal technique using linear and nonlinear filters," in International Conference on Electrical, Electronics, Communication, Computer and Optimization Techniques (ICEECCOT 2017), 2017.

[5] D. K. Priya, B. B. Sam, S. Lavanya, and A. P. Sajin, "A survey on medical image denoising using optimization technique and classification," in International Conference on Information, Communication & Embedded Systems(ICICES), 2017.

[6] IGI-Global, "Speckle noise," 2017. [Online]. Available: https://www.igi-global.com/dictionary/speckle-noise/51819

[7] S. Rao, C. K. Rekha, and D. K. Manjunathachari, "Speckle noise reduction in 3d ultrasound images – a review."

[8] A. S, L. Kola, S. P, and A. S, "Analysis of filtering and novel technique for noise removal in MRI and CT images," in International Conference on Electrical, Electronics, Communication, Computer and Optimization Techniques (ICEECCOT), 2017.

[9] Z. Chen and L. Zhang, "Multi-stage directional median filter," 2009 International Journal of Electrical, Computer, Energetic, Electronic and Communication Engineering, vol. 3, p. 11, 2009.

[10] "Wiener filter," 2018. [Online]. Available: https://en.wikipedia.org/wiki/Wiener_filter

[11] M. A. Sankari and D. S. Vigneshwari, "Automatic tumor segmentation using convolutional neural networks," in Third International Conference on Science Technology Engineering & Management (ICONSTEM 2017), 2017.

[12] P. R. Katre and A. Thakare, "Detection of lung cancer stages using image processing and data classification techniques," in 2nd International Conference for Convergence in Technology (I2CT 2017), 2017.

[13] X. Zhang, S. Cheng, H. Ding, H. Wu, R. Cheng, and N. Gong, "Ultrasound medical image denoising based on multi-direction median filter," in 8th International Conference on Information Technology in Medicine and Education, 2016.

[14] M. Hozaki and A. P. Pawlovsky, "A new way of applying spatial filters and wavelets to reduce noise in medical images," in 2016 IEEE Region 10 Conference (TENCON), 2016, IEEE Region 10 Conference.

[15] D. L. Donoho, "De-noising by soft-thresholding,," IEEE Trans. on, 1995.

[16] A. Buades, B. Coll, and J. M. Morel, "A non-local algorithm for image denoising," IEEE Computer Vision and Pattern Recognition, vol. 2005, no. 2, pp. 60–65, 2005.

[17] M. Mihcak, I. Kozintsev, K. Ramchandran, and P. Moulin, "Low complexity image denoising based on statistical modeling of wavelet coefficients,," vol. 6, pp. 300–303, 1999.

[18] A. R. J. Begum and T. A. Razak, "Diagnosing leukemia from microscopic images using image analysis," in 2017 World Congress on Computing and Communication Technologies (WCCCT), 2017.

[19] S. Gupta and R. K. Sankaria, "Real-time salt and pepper noise removal from medical images using a modified weighted average filtering," in Fourth International Conference on Image Information Processing (ICIIP), 2017.