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Analysis of Pre-processing Techniques on CT DICOM Images

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Abstract— In the present days, cancer has become a menacing disease. Lung cancer is the foremost cancer affecting both men and women throughout the world. In this regard, biomedical imaging is a technology that aids fundamental medical investigations. Some of the widely applied biomedical imaging techniques are Computed Tomography (CT), Magnetic Resonance Imaging (MRI), etc. Among the imaging techniques, CT images are generally used for detecting life frightening pathologies. CT images present high spatial resolution including contrast deviation in tissue. However, CT images are prone to Gaussian noise due to thermal energy fluctuations. Also CT images get affected by artifact and structural noise which hamper correct diagnosis. To overcome this problem, different de-noising filters like Median filter, Gaussian filter, Box filter, Average filter, X-filter are applied on CT images before further processing. In order to identify the superlative filter metrics like SNR (Signal to Noise Ratio) and PSNR (Peak Signal to Noise Ratio) are used. The CT image dataset in (Digital Imaging and Communications in Medicine) DICOM format provided by the (Lung Image Database Consortium) LIDC has been utilized to perform the analysis in the present work.

Keywords— *CT, SNR, PSNR , Filter, DICOM*

I. INTRODUCTION

Medical imaging is a method and way of visual depiction of internal parts of human body [3]. Medical imaging is a blooming technology used for diagnosing the patient's abnormalities. There are many modalities [3] like CT, PET, and MRI etc. Majorly, the CT is the initially preferred modality used for cancer detection. CT scan, a superior, influential x-ray facilitates imaging of inner organs. In CT, a gleam of X-rays rolls across the person being examined and is picked up via amenable energy detectors subsequent to penetration of the inner organs from multiple angles. A computer subsequently examines the details acknowledged from the CT detectors, as well as builds a complete image of the inner organs. Compared to other imaging techniques CT scan provides better detail of the images.

Cancer is a disorder which occurs when there is uncontrolled increase of cells in human body. The growth can invade or stretch to further parts of the body. Symptoms of Cancer are varied and it depends on the volume and the type of organ affected. Cancerous cells hamper the normal functioning of the human body. Few of the common symptoms of cancer are increase in body temperature, weariness, extreme sweating, anemia, and mysterious mass reduction. Treatments given for cancer in general are hormonal therapy, targeted therapy, immune therapy, radiation therapy, surgery, gene therapy and chemotherapy. Surgery is the principal means of handling for last stage cancers. Cancer detection is done using any of these methods like objective inspection (biopsy), blood or urine tests, or medical imaging. Medical imaging plays an extremely crucial role in diagnosing cancer without the need to cut open the body of the patient. Lung cancer in general is the uncontrolled development of irregular cells in one or both lungs that can be better detected using CT images.

During image acquisition and transmission of CT images, noises get added on to the images. So to remove these noises, filters are used. The pre processing of CT medical images consists of removing noises before further processing. There are many pre processing filters like Median filter, Gaussian filter, Box filter etc. that can be used for removing the noises.

In the subsequent section, various filters used in the pre processing stage of lung cancer detection are conversed.

II. RELATED WORK

Lung cancer is the foremost cancer affecting both men and women throughout the world. Many studies have been conducted and are still being conducted to detect lung cancer at

an early stage. In this section, an outline of research works carried out to detect lung cancer is discussed.

Suren Makaju et al. [1] propose a model consisting of initial processing of images to eliminate random variations followed by image partitioning techniques. During the initial processing stage, the filters like median and Gaussian are employed to eliminate the random variations in the image. Kamil et al [2] proposes to use median filter to lessen the random variations in CT images while maintaining the fine points. The median filter concurrently minimized noise and preserved edges. Aarthi et al. [3] explain the different image modalities like ultrasound, CT, MRI stressing more upon the ultrasound images. Hasan Koyuncu et al. [4] propose a denoising process using Block Matching and 3D Filtering (BM3D) method intended for removal of noise. Brij Bhan et al. [5] discuss contrast enhancement methods using the blend of contrast limited adaptive histogram equalization and discrete wavelet transform methods to apply on medical images. M.Jayanthi [6] converts the standard DICOM images into gray level images before further processing. Median filter is then applied to get rid of unnecessary variations in images. Khobragade et al. [7] propose segmentation of lungs, its feature extraction plus classification using artificial neural network method designed in support of finding lung ailments like TB, lung cancer of the lungs as well as pneumonia. Carlos Ciompi et al. [8] presents a new method for categorizing pulmonary nodules. The method uses nodule morphology like bigotry of nodules, vascular constitution along with depiction of conjecture. Md. Badrul Alam et al. [9] have used binarization method for preprocessing. The system uses stages such as acquiring of image, pre processing, binarization, thresholding, segmentation, feature extraction, and neural network detection [9]. Ritika Ankit Rajet al. [10] have reviewed the literature on finding lung malignancy via medical content based image retrieval. They have provided content support based image reclamation Computer Aided Diagnosis System (CAD) intended for lung cancer detection at the early stage using the CT images.

III. PRE PROCESSING

CT images widely supports planning and follow up actions necessary during the course of cancer stages. Further CT scans can expose the presence of tumours and lesion, along with the spread, position and deepness of tumour. Noise in CT is an unnecessary change in pixel values in an otherwise homogenous image. The noise in CT images essentially condenses the visibility of small distinct objects. CT images are prone to Gaussian noise owing to the appearance of electrical signals. The presence of random noise also confines the capability of the medical practitioners to discriminate between tissues of varying density.

Pre processing is a technique adapted to remove noise present in the image and sharpen the edges. An image filtering algorithm produces an output pixel by examining the neighbourhood of each of the input pixel in an image. Various filters like Median filter, Gaussian Filter, Box filter are applied to eliminate the random variations present within the CT image.

A. Median filter

The median filter operates by affecting the image pixel by pixel, substituting every value by the median of adjoining pixels in the window w. The median is calculated by

$$G(x,y) = \{ \text{median}\{f(i,j),\ (i,j)\text{Ɛ } w\} \quad \text{(i)}$$

where w characterizes a neighborhood centered around the locality [x,y] in the image.

B. Gaussian filter

A Gaussian kernel provides more weight to pixels in close proximity of the current pixel and smaller weight to far pixels when calculating sum. The nature of the Gaussian function is dogged based on the standard deviation.

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}} \quad \text{(ii)}$$

where σ is the standard deviation of the allocation encompassing the input image.

C. Box filter

Box filtering is applied based on the average of adjoining pixel encompassing the image. In filtering process, image model and the filter core are multiplied to obtain the output result.

$$G(x,y) = \begin{cases} 1 & \text{if } -X \le x \le X \text{ and } -Y \le y \le Y \\ 0 & otherwise \end{cases} \quad \text{(iii)}$$

where G(x,y) represents the filtered image.

D. Average filter

The average filter working is by affecting the image pixel by pixel, restoring every value by the average value of adjacent pixels. It is calculated by

$$G(x,y) = \frac{1}{mn} \sum_{k\epsilon m} \sum_{l\epsilon n} f(k,l) \quad \text{(iv)}$$

E. X-filter

The X-filter are non-linear spatial filters where the retort is dependent on the organization of the pixels confined in the image region contained within the filter and subsequently restoring the value in the middle pixel with the value dogged by means of the organization result.

Based on the application of the above filters, results are tabulated based on the SNR and PSNR values. SNR is given as the relation of the mean value of the signal and the standard deviation of the noise. SNR is assessed independent of the nature of noise being analyzed. But the consequence

and usability of the parameter is especially dependent of the kind of noise.

PNSR (Peak Signal to Noise Ratio) is a feature measure linking the original image and a image being tested. The high PSNR value indicates the healthier value of the image. PSNR basically characterizes a measure of the peak error. To determine PSNR value, MSE (Mean Squared Error) values are computed first using the equation:

$$MSE = \frac{[\sum_{M,N} I1(m,n) - I2(m,n)]^2}{M * N} \quad \text{(v)}$$

The PSNR values are then determined by the formula:

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

A range of filters are applied on images and the SNR and PSNR values are found out. The filters like median Filter, Gaussian Filter, Box filter, Average Filter, X Filter are applied on Lung CT DICOM images. The Table I are tabulated with SNR results and Table II are tabulated with PSNR results respectively.

TABLE I
SNR OF DIFFERENT FILTERING TECHNIQUES

FILTERING TECHNIQUES	CT SCAN IMAGES				
	1	2	3	4	5
Gaussian Filter	19.51	20.29	21.07	22.09	20.53
Box Filter	19.62	20.45	21.04	22.5	20.68
Average Filter	19.5	20.26	21.04	22.03	20.49
Median Filter	21.47	21.69	23.01	23.87	21.8
X Filter	24.52	25.02	24.12	26.28	24.84

TABLE II
PSNR OF DIFFERENT FILTERING TECHNIQUES

FILTERING TECHNIQUES	CT SCAN IMAGES				
	1	2	3	4	5
Gaussian Filter	35.21	32.68	37.58	34.14	32.24
Box Filter	35.18	32.73	37.45	34.46	32.28
Average Filter	35.06	32.54	37.45	33.99	32.10
Median Filter	37.03	33.97	39.42	35.83	33.40
X Filter	40.08	37.30	40.53	38.23	36.45

IV. RESULTS AND DISCUSSION

Pre processing is basically required to eliminate random variations in the image and sharpen the edges. The filters are applied to eliminate noise. The results of the application of filters on lung CT DICOM images are graphically represented in figure 1.

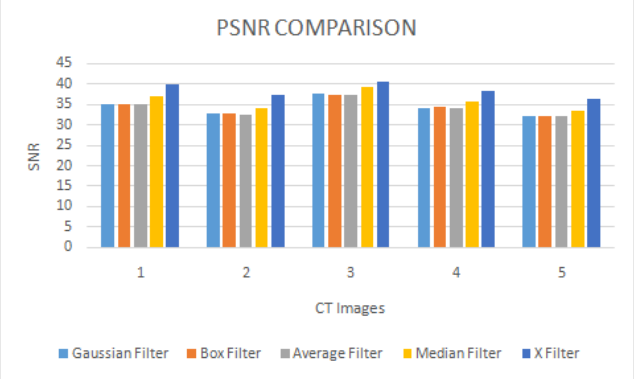

Figure 1: PSNR of different filtering techniques

Table 2 shows the PSNR values of every tested filters specifically Median filter, Gaussian filter, Box filter, Average filter and X filter. The application of the corresponding filters on lung CT images can be viewed in figure 2. Figure 2 shows the original images and the corresponding images after the application of filters. The results confirm that X filter produces the highest PSNR compared to other filters. Thus, it can be concluded that X-filter offers the improved PSNR value with better clarity

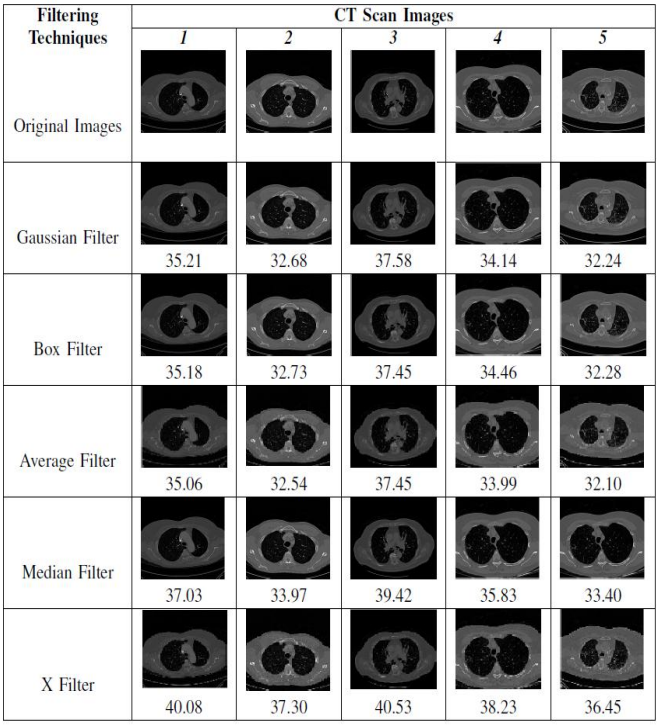

Figure 2: Original images and the corresponding images after filtering

V. CONCLUSION AND FUTURE SCOPE

The current systems for cancerous nodule dection consist of segmentation process followed by classification. But, before

performing segmentation, image preprocessing is very much necessary as this improves the results of further stages. So in this paper, the application of various filters and its corresponding results are analyzed . Various de-noising filters applied are Median filter, Gaussian filter, Box filter, Average filter and X-filter. From the results, it can be analyzed that X filter bestows the superior PSNR value compared to any other filter. The work can be further validated by testing on a larger dataset.

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