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High Boost Filtering Technique for Denoising CT Images for Lung Cancer Detection

Dr. Manjula. T
Assistant Professor
Dept. Of Computer Science
Seshadripuram College, Tumakuru

Abstract: In order to cure lung cancer early detection of cancer is necessary. Computer aided diagnosis (CAD) technology is used for detection in which CT image is segmented for lung nodules and then after further processing, detection will be done. Machine learning classifiers (KNN, SVM, etc) are used for classification and detection. Noise is induced in the image during acquisition or transmission; there is reduction in performance of detection because it may alter the coefficients which are required for classification. The proposed method is used to filter the image and then subject it to detection, So that performance can be improved compared to detection without filtering.

***Index Terms* - specificity, segmentation, feature extraction**

I. INTRODUCTION

Lung cancer has highest number of deaths compared to other cancers. Patients who undergo Computed Tomography (CT) scanning yearly showed a 20% less death rate. This death rate can be further reduced by using CAD to diagnose cancer. Diagnosing the cancer in early stages is very necessary in prevention and treatment of lung cancer. As per the survey in China about 6, 30,500 deaths occurred due to lung cancer in 2020. Survival rate is only 19.5% for five years [1].

Computed Tomography (CT) is more sensitive compared to computed radiography as per National Lung Screening Trail. If we use CT,death rate can be decreased by nodule 20% [2]. In early stage of lung cancer one of the sign which is seen in CT is pulmonary nodules which is an abnormal growth in lungs. It may be one or several nodules. The growth should be smaller than 3cms in order to consider it as a nodule. These nodules are called as “spot on the lungs”.

In CT scan image noise can appear which is unavoidable. Every medical image contains noise. Many minor details may be hidden by noise, so noise removal plays an important role in diagnosis of lung cancer using CT scan images. The quality of the image is decided by the number of pixels corrupted in the image. The noise in image can be classified as Gaussian or Amplifier noise, shot noise, salt and pepper noise, poison noise and speckle noise. Study of noise is very much needed because each noise has its own properties and drawbacks.

In noise with Gaussian distribution probability density function is equal to the normal distribution. The main source of Gaussian noise in CT image is raised during acquisition due to electronic circuit noise in sensors. Impulse noise is a short duration noise occurs usually due to atmospheric disturbances such as interference of channels, switching during image acquisition, variation in sensor temperature etc.

Impulse noise is randomly distributed over the image which is uncorrelated to the image pixels. Only certain pixels are corrupted not all due to impulse noise in an image. Salt and pepper noise and random valued noise are the two type of impulse noise. Poison noise occurs in an image which is obtained by accumulation of photons over a detector. Due to statistical nature of electromagnetic waves such as X ray, gamma rays, visible light etc poison noise appear in an image. When these rays are used for acquisition of image its sources have random variation of photons per unit time. Speckle noise or texture noise is a random and deterministic noise which is an impact of using ultra sound imaging induced in image.

II. EXISTING METHODS

Segmentation of lung nodule is done in an image and then classifiers are used to detect nodule and non nodules by many researchers. Machine learning algorithms are generally used for classification and detection of lung cancer. Some of these machine learning includes, Logistic Regression, Naïve Bayes, Stochastic Gradient Descent, K-Nearest Neighbors, Decision Tree, Random Forest,Support Vector Machine [3]. Deep Neural Network is also combined with above algorithms these days. The machine learning classifier can also be used to classify type of cancer cell. The removal of noise from the image is obligatory before detection; many methods are proposed for filtering image. Selective filtering algorithm [4] is one of the techniques to filter image in which filter are altered based on the regions of the image. Even if the filters remove noise but it also blur’s the fine information of the image. This algorithm is used for image with noise density less than 50%. Weighted non local mean algorithm [5] is used to remove noise image from Gaussian noise. It removes noise by preserving certain features not all, filtering usually blur’s edges. Adaptive weighted average (AWA) [6] is another method is to remove noise but this method also over smooth edges.

Wavelet based denoising has higher performance compare to spatial method but create artifact around the edges. A fast and efficient algorithm [7] is used to remove Gaussian noise based on amount of pixels corrupted in the image. A hybrid novel algorithm is used to remove impulsive noise. The intension of the proposed method is to filter the image so that important information’s like edges does not get blurred. Early lung cancer detection [8] based on the analysis of sputum color images is proposed. A set of features is extracted from the nuclei of the sputum cells after applying a region detection process. Two classification techniques: artificial neural network (ANN) and support vector machine (SVM) to increase the accuracy of the CAD system. The lung regions in CT scan images are segmented using optimal thresholding[9]. To find the region of interest region growing method is used. Two types of parameters textural and statistical are calculated and analyzed separately. The feature set is applied to the multilayer feed forward back propagation neural network is measured in terms of mean square error (MSE).

III.METHODOLOGY

The steps to be followed for detection of lung cancer are as follows.

Pre-processing: Pre-processing is done to remove noise and artifacts from CT image to improve the quality of the image and to enhance the detection of relevant information.

Lung segmentation: Important step in detection of lung cancer is lung segmentation in which lung nodules are identified from the CT images; pulmonary parenchyma is segmented from other tissue and organs.

Lung nodule detection: In this step all pulmonary nodules are detected from CT scan images then sizes of the nodules are calculated to identify benign and malignant nodules. Each nodule is segmented from lung parenchyma using DISC similarity coefficient (DSC) segmentation performance can be assessed in CAD system.

Lung nodule classification: CAD system is used to classify the benign and malignant nodules which will help in detecting patient having lung cancer this step required high accuracy.

IV.PROPOSED METHOD FOR DENOISING

In proposed method iterative median filter is applied iteratively which smoothens edges but removes most amount of noise. The edges and fine information which is lost can be retried by using high boost mechanism. Low pass filter is applied to remove further irregularities in image after median filtering, the filter function of low pass filter is given by equation (1)

$$H(x,y) = \begin{Bmatrix} 1\ D(x,y) \leq D0 \\ 0\ D(x,y) > D0 \end{Bmatrix} \tag{1}$$

D0 is positive constant which act like a transition between H(x,y)=1 to H(x.y)=0 and D(x,y) is distance between point (x,y)and center of rectangle. H(x,y) is a transfer function of the filter. x,y indicate frequency variable of space of Fourier transform. This filter suppresses all higher frequencies remaining frequencies remain unaltered, following steps are applied while filtering.

1Multiply input image with $(-1)^{p+q}$ where p,q indicate number of rows and columns in image for centering.

2. Calculate Discrete Fourier transform (DFT) of image let it be F(x,y)

3. Filteringis done by multiplying F(x,y) with H(x,y).

4. Do inverse of DFT(IDFT) for the above product.

5. Multiply result obtained with $(-1)^{p+q}$ to decentralize.

Low pass image filter and its filtered image as shown in figure 1

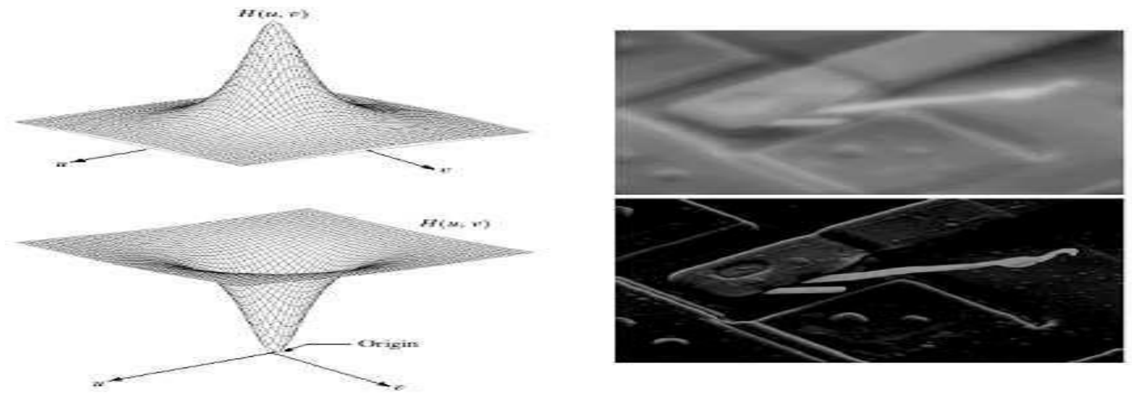

Figure 1(a) shows low pass and Figure 1(b) shows high pass filtering of image.

High pass filter is defined by the equation 2. High pass filter and its filtered image as shown in figure 1.

$$H(x,y) = \begin{Bmatrix} 1 \; D(x,y) \geq D0 \\ 0 \; D(x,y) < D0 \end{Bmatrix} \quad (2)$$

High pass boosting is done to recover the edges lost due to filtering this is done by using the following steps below.

1. let f(x, y) indicate the image after applying median filter more than 4 times.

2. Apply low pass filter to f(x,y) to get low pass filtered image $f_l(x,y)$

3. Subtract $f_l(x, y)$ from f(x, y) to get mask image $f_m(x, y)$

$$f_m(x,y) = f(x,y) - f_l(x,y) \quad (3)$$

4.Mask image is multiplied by a scaling factor. Let it be α and then added with f(x, y) to get the high boost image $f_b(x, y)$ as indicated in equation (4)

$$f_b(x,y) = f(x,y) + \alpha \times f_m(x,y) \quad (4)$$

$f_b(x, y)$ is the Resultant image after applying high boost filter this image is to the further process of lung detection as explained in section III.

V. RESULTS AND DISCUSSION

Image is applied for detection of lung cancer, noise may be added which reduce the quality of detection. The parameters which are used to compare the methods of detection with their formula to calculate are given below.

$$Accuracy = \frac{(TP+TN)}{Total} \quad (5)$$

$$Precision = \frac{TP}{(FP+TP)} \quad (6)$$

$$Prevalence = \frac{(TP+FN)}{Total} \quad (7)$$

$$Sensitivity = \frac{TP}{(TP+FN)} \quad (8)$$

$$Specificity = \frac{TN}{(FP+TN)} \quad (9)$$

$$misclassification\ rate = \frac{(FP+FN)}{Total} \quad (10)$$

$$True\ positive\ rate = \frac{TP}{(FN+TP)} \quad (11)$$

$$False\ positive\ rate = \frac{FP}{(TN+FP)} \quad (12)$$

$$True\ Negative\ rate = \frac{TN}{(TN+FP)} \quad (13)$$

TP →True Positive, TN →True Negative, FP →False Positive, FN →False Negative Total→ Total number of samples (CT images) under observation. TP, TN, FP, FN are the outputs of confusion matrix.

For comparison first noise is added to the CT image and then detection is done using method explained in section 3. The parameters are determined to check quality of detection values are tabulated in table 1.

Table1: Comparison of accuracy and other parameter for detection with noise and after filtering.

Parameters	Image with Noise	After applying proposed method for image with noise	Image without noise	After applying proposed method for image without noise
Accuracy	0.611111	0.777778	0.888889	0.944444
Precision	0.5625	0.692308	0.818182	0.9
Prevalence	0.5	0.5	0.5	0.5
Sensitivity	1	1	1	1
specificity	0.222222	0.555556	0.777778	0.888889
Misclassification rate	0.388889	0.222222	0.111111	0.0555556
True positive rate	1	1	1	1
False positive rate	0.777778	0.444444	0.222222	0.111111
True negative rate	0.222222	0.555556	0.777778	0.888889

It can be observed that accuracy and other parameters of lung cancer detection for CT/MRI images with noise is reduced compare to CT/MRI images without noise. Filtering using proposed method is applied on CT/MRI images with noise then detection is done which resulted with increase in performance (Increase in accuracy value etc).If the CT/MRI image without noise is filtered using proposed method then we can observe further improvement in values of performance parameters compared to detection without filtering.

Screenshots of the Experimental Results

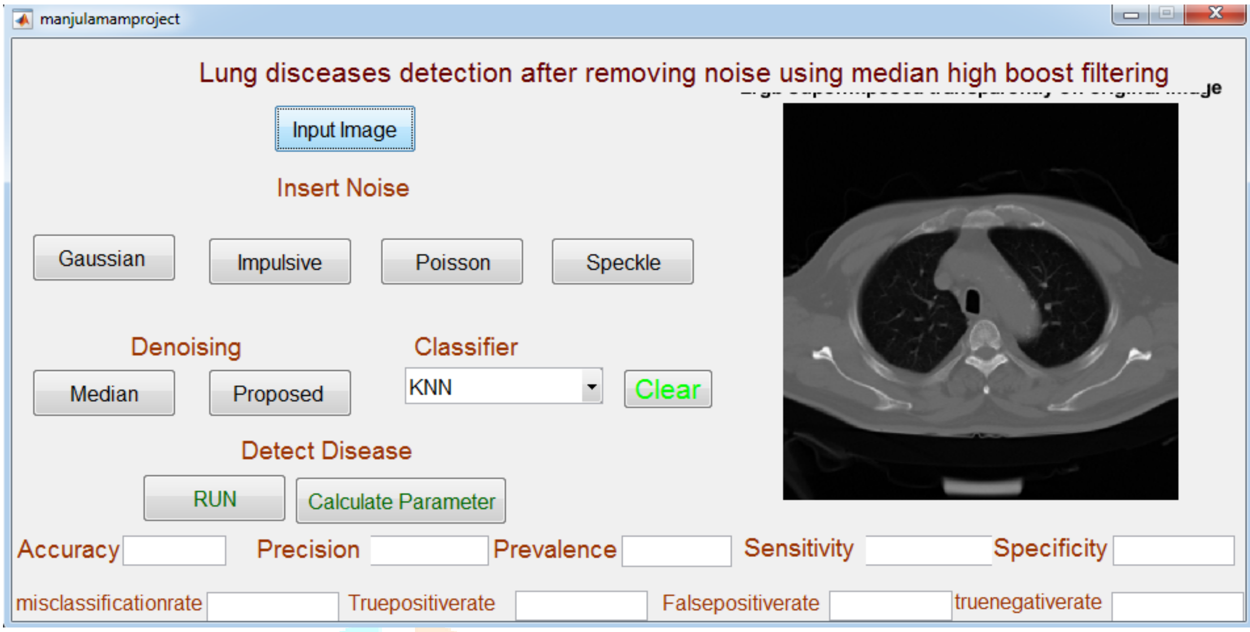

Figure 2: selection of Input image

Figure 2, above shows the working model of lung nodule detection GUI; in this we have selected the input image, which is the CT scan image obtained from the radiologists.

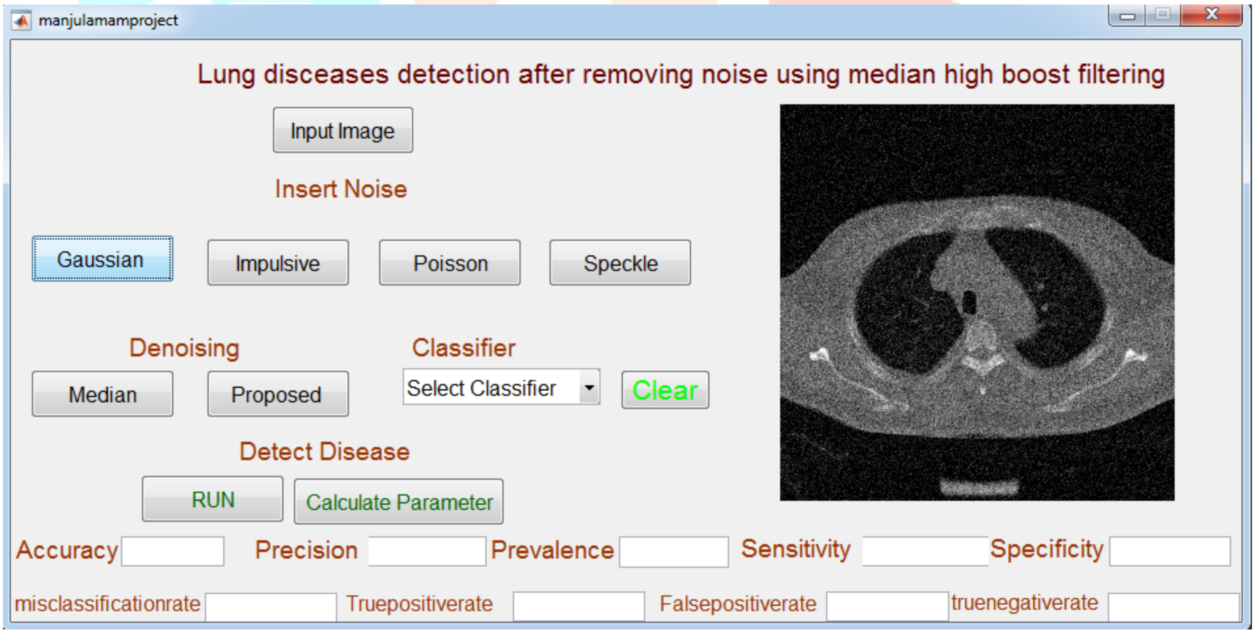

Figure 3: Input image with Gaussian noise

In the selected input CT image, the Gaussian noise is added as shown in the figure 3, we can observe the noise in the image.

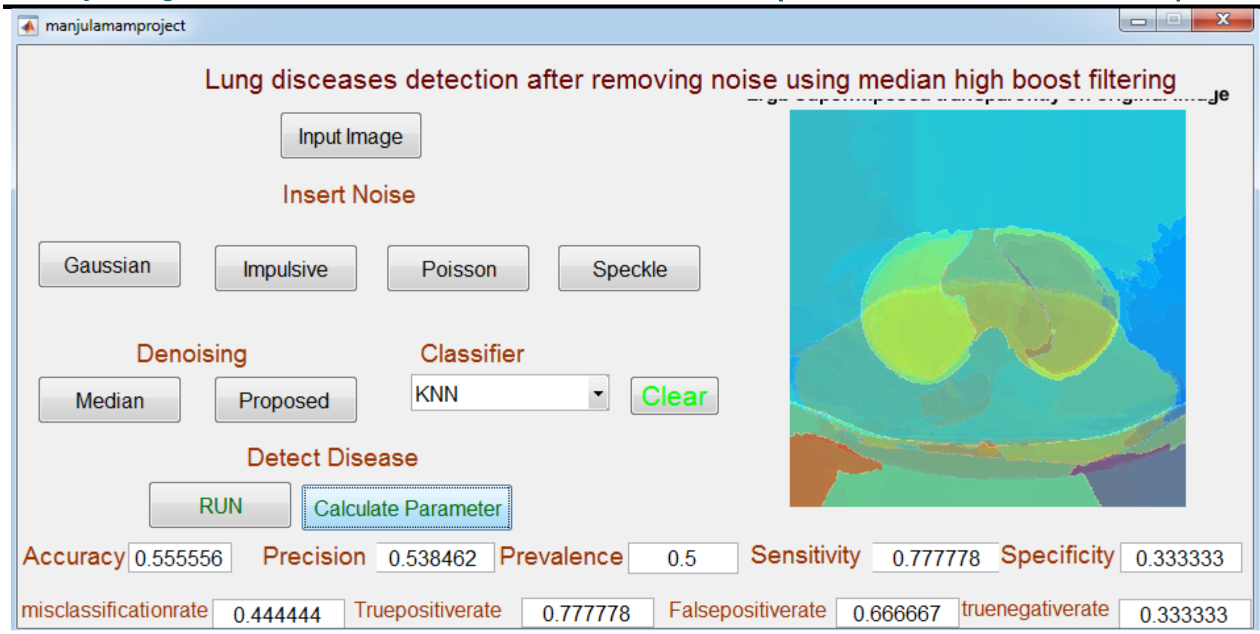

Figure 4: Gaussian noise with K-Nearest Neighbour classification and parameter analysis

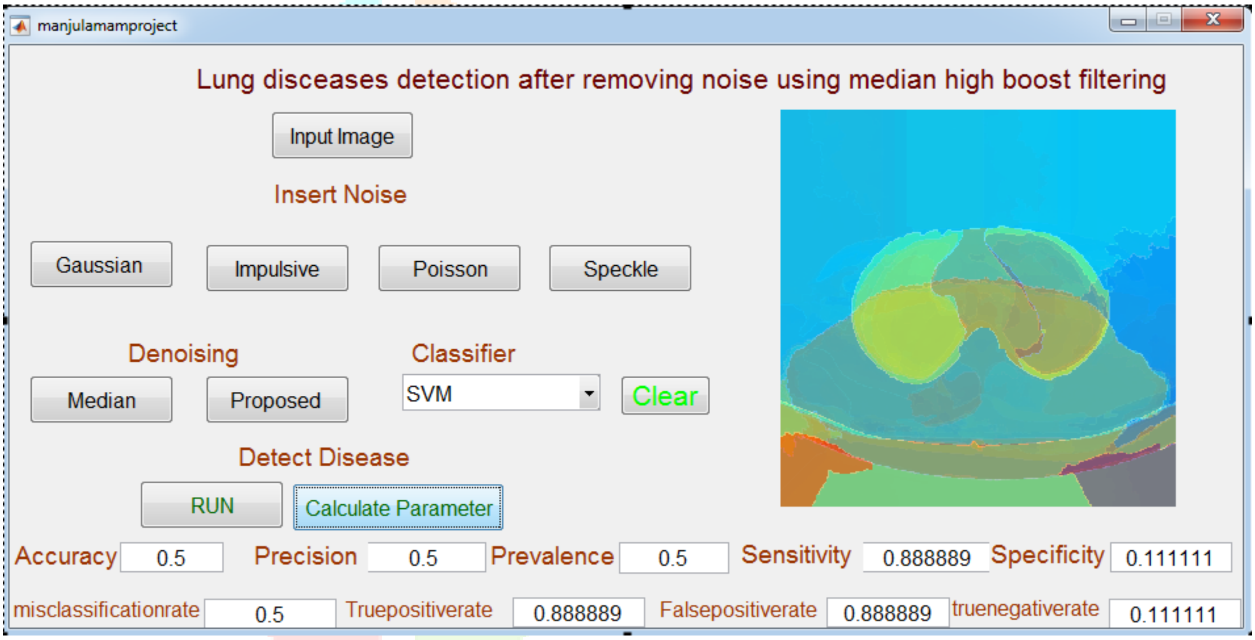

Figure 5: Gaussian noise with Support Vector Machine classification and parameter analysis

Figure 4 and Figure 5, gives the performance of analysis of KNN and SVM classifiers.

CONCLUSION

Noise is added to CT image during transmission and acquisition. Different types of noise are added such as Gaussian, impulsive, Poisson, Speckle noise; it has to be removed before subjecting for detection. Proposed method is used for filtering in such a way that the fine information is not lost as in median filter. The results show that after applying proposed method the performance of detection process is enhanced. It can also be observed that when the proposed filter method is applied to the CT image without noise, then detection results in increase in performance parameters. The proposed method uses high boost filtering approach, which filter image without smoothening edges of image and help in accurate detection of cancer. So that it can be cured in early stages. If we use Denoising method using deep neural network further improvement in performance can be achieved.

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