Enhancing Bronchiectasis Diagnosis Through (MATLAB-Based Image Processing Methods).

Liala Taher Essa El essawi

University of Medical Sciences and Technology - Tripoli.

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ABSTRACT

Medical image processing has long been recognized as an effective and purposeful tool for identifying pathological changes in radiological images. In this study, MATLAB was utilized to apply image processing techniques aimed at detecting bronchiectasis.

Chest CT scans were obtained from a patient's archive, including images captured in 1998, 2007, 2008, and 2012. These images were reviewed by respiratory specialists for two main purposes:

- First, to compare the images longitudinally and monitor any changes in the patient's condition, whether improvement or deterioration.
- Second, to evaluate the effectiveness of MATLAB-based image processing applications in enhancing diagnostic accuracy and identifying the most suitable technique to assist clinicians.

This study focused on two CT images from 1998 and 2012, applying various MATLAB commands to both scans to detect regions affected by bronchiectasis. The processing involved segmentation, enhancement, and comparative analysis, with the results assessed by pulmonologists to determine the most effective method for clinical interpretation.

الملخص

لطالما اعتُبرت تقنيات معالجة الصور الطبية MATLAB من الأدوات الفعالة في تحليل التغيرات المرضية الظاهرة في الصور الشعاعية. وفي هذا السياق، تم توظيف برنامج لتطبيق تقنيات معالجة الصور بهدف الكشف عن الحالة المرضية المتمثلة في توسع الشعب الهوائية.(Bronchiectasis)

تم الحصول على صور الأشعة المقطعية للرئتين من أرشيف أحد المرضى، وتشمل الصور المأخوذة أعوام 1998، 2007، 2008، و2012. وقد تم عرض هذه الصور على مجموعة من أطباء الجهاز التنفسي لتحقيق هدفين رئيسيين: -

أولًا، إجراء مقارنة زمنية بين الصور لتقييم تطور الحالة المرضية، سواء من حيث التحسن أو التدهور.

ثانيًا، دراسة فعالية تطبيقات MATLAB المختلفة في تحسين جودة الصور وتسهيل عملية التشخيص، بهدف تحديد أفضل تقنية معالجة يمكن أن تدعم الأطباء في اتخاذ القرار السريري.

في إطار هذه الدراسة، تم التركيز على صورتين شعاعيتين من عامي 1998 و2012، حيث طُبقت مجموعة من أوامر MATLAB على كلا الصورتين للكشف عن المناطق المتأثرة بتوسع الشعب الهوائية. وقد شملت هذه العمليات تقنيات التجزئة والتحسين والمقارنة، وتم تقييم النتائج من قبل أخصائي أمراض الجهاز التنفسي لتحديد مدى دقة وكفاءة كل تطبيق في دعم التشخيص الطبي.

1. INTRODUCTION

The revolution in the field of information technology along with digital imaging in the medical domain facilitates the generation and storage of large collection of images which are an important source of anatomical and functional information for the accurate diagnosis of diseases. The most common imaging procedure used for diagnosis of lung disorders is the chest *X-ray* because of its low costs and weak radiation exposure. However, chest *X-rays* are negative in a large portion of diseases and often unspecific. *Computed tomography (CT)*, which allows the radiologist to look at the lung in cross-section rather than from the outside, has helped them to understand physiologic abnormalities in the lungs and make more accurate diagnosis. *High-resolution computed tomography (HRCT)* of the chest often provides more information for *diagnostics of Interstitial Lung Diseases (ILDs).* Although skilled radiologists have a high degree of accuracy in diagnosis of lung disorders using advanced CT imaging technology, there remain challenges that cannot be overcome even by high levels of clinical skill and expertise especially in such lung diseases like ILDs that are characterized by specific abnormal findings and frequently confusing symptoms as discussed. The problem is first to find efficient features for image representation, then to use an effective measure to establish similarity between two images. The features and the similarity measure should be efficient enough to match similar images as well as to discriminate dissimilar ones. In this work, we have developed a *MAT LAB* system that can be used as an aid for physicians to diagnose *bronchiectasis. Bronchiectasis* is a congenital or acquired disorder of the bronchi of the lungs, characterized by permanent, abnormal dilation, and destruction(D. Shiloah Elizabeth, 13 July 2009). *Matlab* is a data analysis and visualization tool which has been designed with powerful support for matrices and matrix operations. As well as this, *Matlab* has excellent graphics capabilities, and its own powerful programming language. One of the reasons that *Matlab* has become such an important tool is through the use of sets of *Matlab* programs designed to support a particular task. These sets of

programs are called toolboxes, and the particular toolbox of interest to us is the image processing toolbox .(Alasdair McAndrew)

Poor clarity in CT chest images leads to uncertainty in diagnosing lung disorders. This research aims to enhance image quality using Matlab to improve lung damage diagnosis. The primary goal is to facilitate the computational detection of disorders, while the secondary goal is to differentiate between diagnostic cases and help identify subtle damage that may not be easily visible or diagnosable.

Importance

This study is significant because it:

- Introduces modern techniques and research aimed at improving image quality and optimizing resource use.
- Reviews conclusions and recommendations that identify areas for enhancing the CT chest imaging program to achieve perfection.
- Encourages others interested in image quality enhancement to adopt recent software and techniques, aligning with advancements in medical imaging

2. **2. Literatures review**

I. Morphological Background Detection and Enhancement of Images With Poor Lighting (Angélica R Jiménez-Sánchez 2009)

In this study , some morphological transformations are used to detect the background in images characterized by poor lighting. Lately, contrast image enhancement has been carried out by the application of two operators based on the Weber's law notion. The first operator employs information from block analysis, while the second transformation utilizes the opening by reconstruction, which is employed to define the multibackground notion. The objective of contrast operators consists in normalizing the grey level of the input image with the purpose of avoiding abrupt changes in intensity among the different regions. Finally, the performance of the proposed operators is illustrated through the processing of images with different backgrounds, the majority of them with poor lighting conditions. Index Terms— Image background, morphological contrast, morphological filters by reconstruction, multibackground, Weber's law

II. Medical Image Enhancement Using Morphological Transformation.(Raihan Firoz1, February 2016)

In this study, morphological transform operation is carried out on medical images to enhance the contrast and quality. A disk shaped mask is used in Top-Hat and Bottom-Hat transform and this mask plays a vital role in the operation. Different types and sizes of medical images need different masks so that they can be successfully enhanced. The method shown in this study takes a mask of an arbitrary size and keeps changing its size until an optimum enhanced image is obtained from the transformation operation. The enhancement is achieved via an iterative exfoliation process. The results indicate that this method improves the contrast of medical images and can help with better diagnosis.

III. An Evaluation of Features Extraction from Lung CT Images for the Classification Stage of Malignancy .(Santosh Singh, p-ISSN: 2278-8727).

This study evaluates CT images of lung, which contains noise. The preprocessing of these obtained images are necessary that is done by using image processing technique such as histogram equalization, thresholding, filtering followed by feature extraction which helps to reduce the process complications as well as accuracy can be improve. Keywords - Accuracy, Computed Tomography Image, Feature Extraction, Image Processing, Sensitivity.

IIII. Lung Cancer Detection Using Image Processing Techniques(Mokhled S. AL-TARAWNEH ,Jordan)

Recently, image processing techniques are widely used in several medical areas for image improvement in earlier detection and treatment stages, where the time factor is very important to discover the abnormality issues in target images, especially in various cancer tumours such as lung cancer, breast cancer, etc. Image quality and accuracy is the core factors of this research, image quality assessment as well as improvement are depending on the enhancement stage where low pre-processing techniques is used based on Gabor filter within Gaussian rules. Following the segmentation principles, an enhanced region of the object of interest that is used as a basic foundation of feature extraction is obtained. Relying on general features, a normality comparison is made. In this research, the main detected features for accurate images comparison are pixels percentage and mask-labelling.

3. METHODOLOGY

The preprocessing steps of the proposed system effectively identify regions affected by bronchiectasis, aiming to enhance image quality. This involves image enhancement techniques such as morphological filtering, edge detection, complementing, and segmentation, all executed using MATLAB. MATLAB's multi-platform environment supports prototyping, data analysis, and visualization, with robust matrix operations and graphic capabilities, facilitating efficient software development. To achieve more accurate results, this research employs various methods: all images are converted from RGB to grayscale and enhanced using default settings. The effectiveness of techniques such as imadjust, imcomplement, adapthisteq, and histogram equalization is compared, alongside morphological filtering supported by the strel object to further enhance the images.

3.1. Data acquisition

Initially, abnormal chest CT images were retrieved from an available medical imaging database. From this dataset, two scans dated 1998 and 2012 were selected for analysis. Preprocessing techniques were applied to enhance image quality and facilitate accurate interpretation. These techniques included contrast enhancement, edge detection, and segmentation, all aimed at improving the visibility of anatomical structures and pathological features. The preprocessing phase of the proposed system plays a critical role in isolating and identifying regions affected by bronchiectasis. Its primary objective is to optimize the diagnostic utility of the acquired images. Following preprocessing, the next stage involves feature extraction, which enables quantitative analysis and supports further classification or diagnostic decision-making.

3.2 Preprocessing

Initially, the image was converted from RGB to grayscale format, retaining only luminance information to facilitate subsequent processing and analysis..

These images are determined as a 2-D array of pixels which is using 8 bits/pixels. Here, a pixel value of 0 is black and value of 255 is white, with intermediate values corresponding to varying shades of gray.

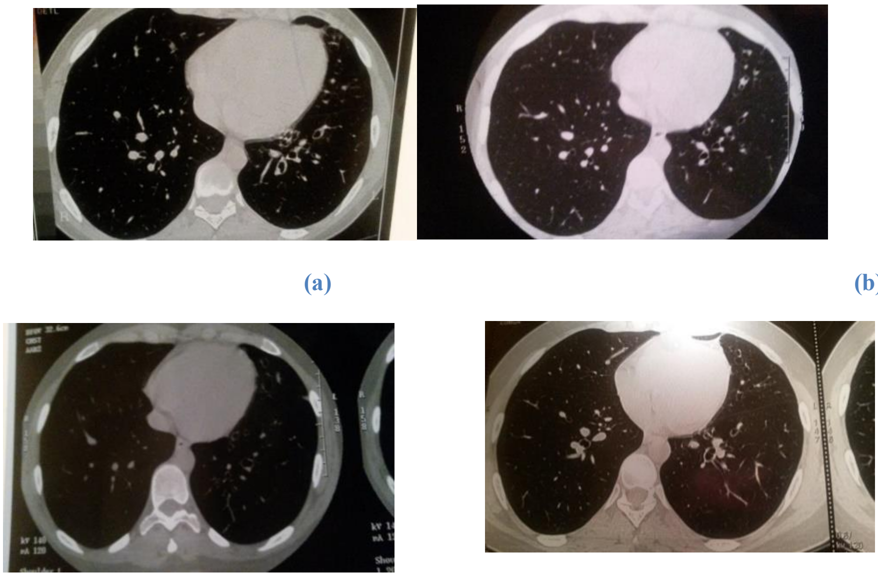
The advantage of converting an image to gray scale is to reduce the processing time and to produce a faster algorithm (Chaudhary A, Singh S S, February 2012)

4. Material and Method

In this study, two primary image processing methods were employed to improve diagnostic accuracy. First, all images were converted from RGB to grayscale format to retain only luminance information, thereby simplifying subsequent enhancement procedures. Grayscale enhancement was performed using default settings to evaluate the effectiveness of several techniques, including imadjust, imcomplement, adapthisteq, and histogram equalization. These methods aimed to improve image clarity and contrast, facilitating better visualization of bronchiectasis regions. Further enhancement was achieved through morphological filtering, utilizing the strel object to perform morphological operations such as opening, which effectively reduced image noise and corrected structural distortions. In the image segmentation stage, enhanced images were processed to isolate regions of interest. This was accomplished using edge detection and basic morphological operations. The Sobel operator was applied to detect edges, leveraging contrast differences between anatomical structures and the background to identify bronchiectasis features with greater precision.

5- Results and Discussion

In this research focused on application of method on original images as showed in figure 1.



(a) (b)

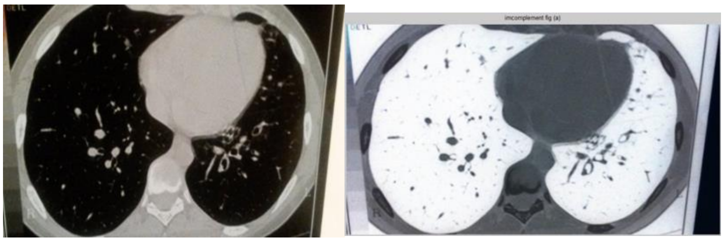
(c) (d)

Figure1. (a)illustrated the Original image CT chest to patient has bronchiectasis taken up in 1998 (b) CT chest same patient taken up in 2007. (c) original image in 2008 (d) original image in 2012

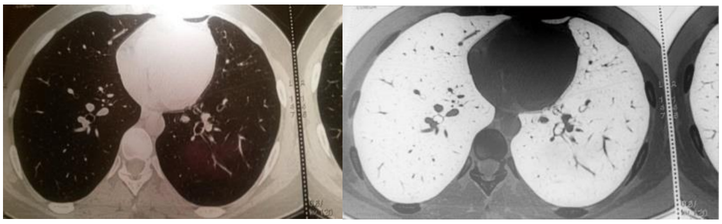
To evaluate the effectiveness of the proposed methods, we selected two representative images: image (a) corresponding to the year 1998 and image (d) corresponding to the year 2012. These images were chosen to demonstrate the application of the techniques across different temporal contexts. The primary objective is to compare the outcomes of the methods when applied to each image, highlighting any variations in performance, enhancement quality, or diagnostic relevance observed between the two datasets.

5.1 First one complement the image.

In the complement of a binary image, zeros become ones and ones become zeros; black and white are reversed. In the complement of an intensity or RGB image, each pixel value is subtracted from the maximum pixel value supported by the class (or 1.0 for double-precision images) and the difference is used as the pixel value in the output image. In the output image, dark areas become lighter and light areas become darker.(MATLAB copyright 1984-2013) Figure 2 describes (a) the original image and (b) the enhanced image using complement technique .



original image (a) *imcomplement* result the image(a)

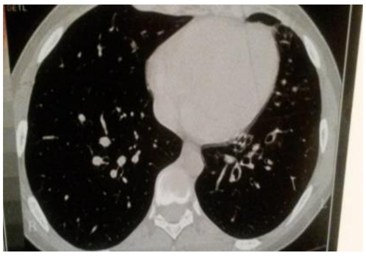
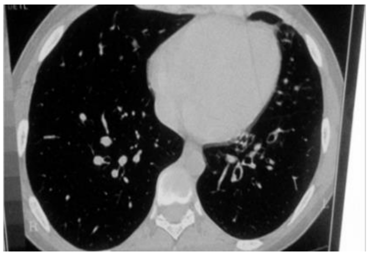


Original image (d) ***imcomplement*** **result the image(d)**

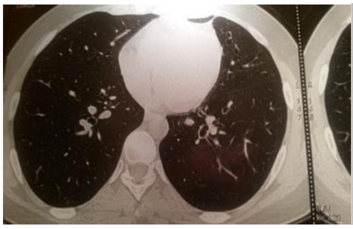
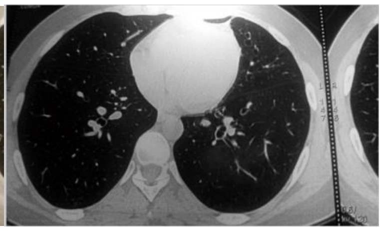
Figure 2 . illustrated The result of applying imcomplement technique on original image (a)and (d)

5.2 Imadjust function

The figure 3 showed Imadjust function maps the intensity values in grayscale image(a)to new values in the result image such that 1% of data is saturated at low and high intensities of original image (a). This increases the contrast of the output image. Adjust a low-contrast grayscale image .the variations that include an input image , the input image can be of class uint8, uint16, int16, single, or double. The output image has the same class as the input image (MATLAB copyright 1984-2013) Figure (3) describes the effect of applying imadjust on original images (a) and (d).

original image (a) ***imadjust* result image (a)**

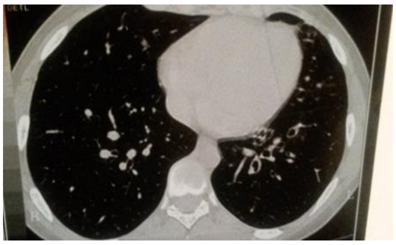
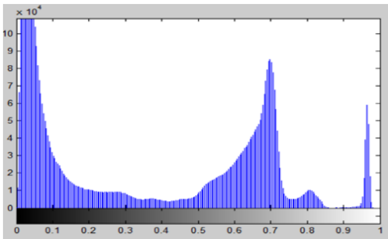



original image (d) **imadjust result on image (d)**

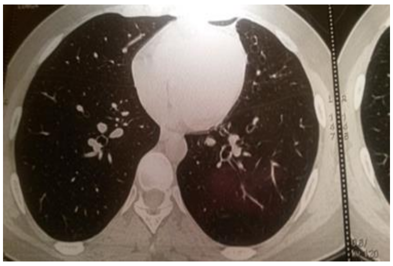
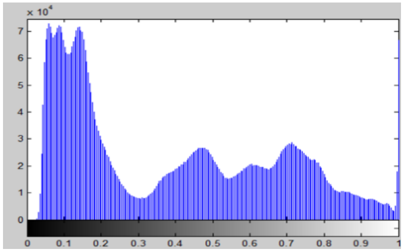
Figure 3. illustrated enhancement technique using imadujst applying on the image (a)and (d)

5.3 5.3 histogram of an images

Calculating and displaying histograms with imhist . The histogram of an image is usually depicted as a bar graph and conveys information about the distribution of the pixel intensities in a predefined number of bins (ranges of intensities), (MATLAB copyright 1984-2013)as we see in figure. 4

Original image **Histogram original(a)**

Original image (d) **Histogram original(d)**

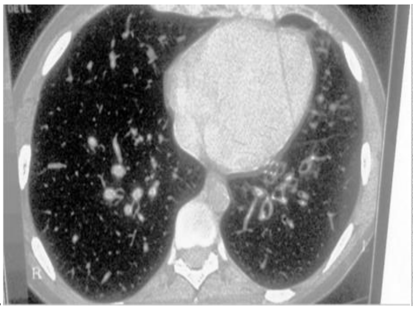
Figure 4 illustrated histogram of an images both (a) and (d).

5.4 Histogram Equalization

The histogram of a monochrome image is a graphical illustration of the frequency of occurrence of each gray level in the image. It reassigns the brightness values of pixels based on the image histogram. Histogram- modeling techniques are used to modify the image so that its histogram has a desired shape. This is helpful in stretching the low-contrast levels of images with narrow histograms. Histogram modeling has been found to be a powerful technique because they are simple, fast and with them acceptable results for some applications can be achieved. The aim of histogram equalization is to obtain a uniform histogram for the output image. Histogram equalization provides more visually pleasing results across a wider range of images. (Santosh Singh). As illustrated in Figure 5,

5.5 Adaptive histogram equalization using adapthisteq

Adapthisteq performs global histogram equalization. When we are done, we can save the function using the name that is already chosen (Contrast Enhancement.). The function includes the two enhancement methods . To choose which one to use on the input image, the method input must be set to if we want to use histeq, if we want to use adapthisteq. The selection is made using the switch case structure, which is a very widely used method in programming. The switch command defines which variable will be checked and the case commands check for all acceptable values and connects them to their respective tasks. The advantage of adapthisteq is that it splits the image in to small rectangular areas called tiles , the function ,adapthisteq can be used with only in put (the image), with all other parameters to default values. (George Siogkas, 2013)



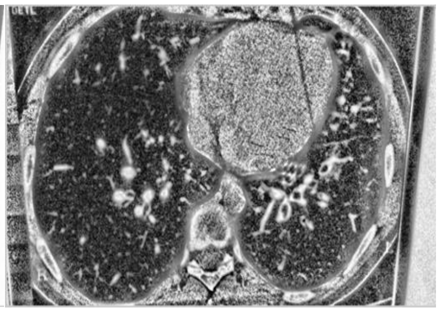
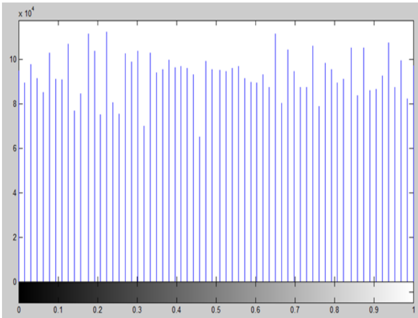
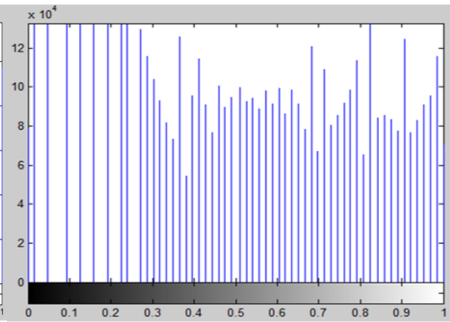


Image histogram equalization(a)

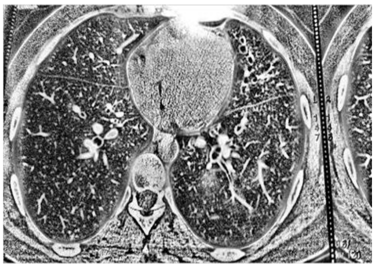
Adaphthisteq result image (a)

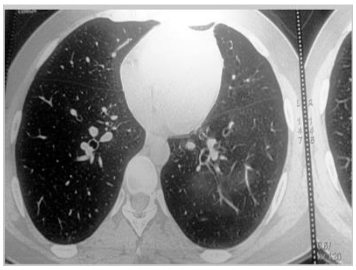




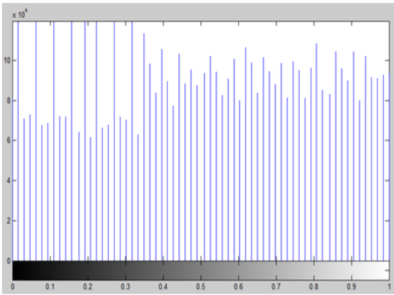
Histogram equalization(a)

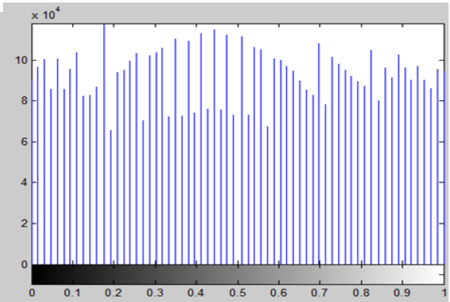
Histogram adapthisteq equalization result (a)





equalization original image (d) **(d)Adapthis eqaulazation image**





Equalization Histogram image (d) **Adapthis histogrameqaulazation image(d)**

Figure .5 illustrated, Histogram equalization and Histogram adapthisteq equalization

The both histeq and adapthisteq have managed to lighten the figure. 5 the left part of the image ,the latter has not only achived better result at it ,but also has avoided saturating smooth areas like hiseq. In order to understand this little better For the time being ,we will have to settle with this artistic contrast enhancement. Of course , which result is more pleasing to the eye is a rather subjective matter, but probably most people would agree that the histequilazation image has more smooth , while The one produced by adapthisteq looks more artistic the image produced using histeq has a rather disturbing high contrast and should be fine -tuned In this application gave special Pulmonologists opinions about the *result adaphisteq gave more dilatation on bronchus bi lateral and that will give inaccuracy diagnosis.*

5.6 Morphological Operations

The main morphological operations are dilation, erosion, closing, opening and the hit-or-miss transform. Among these apply morphology closing (open) on the image. It fills the indentation caused by the pulmonary vessels.(Kumar V, 2013).

Using strel to generate structuring elements The ready – made strel function , provided by image toolbox of matlab ,offers various types of structuring elements. The supported shapes that can used in the problem we used disk and the application on original image was obtained by typing help strel in command. (George Siogkas, 2013). In figures 6 and 7 using morphological filtering the method supported by subtracts Subtract a constant value from an image: strel object , Estimate and subtract the background of an image Create a disk-shaped structuring element with a radius of 15 pixels. by opening it with the disk-shaped structuring element.

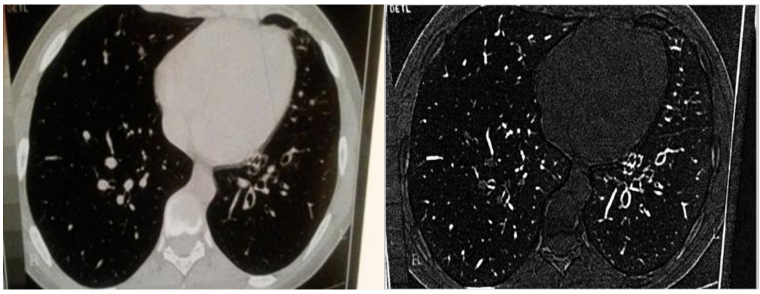


Figure 6 illustrated morphological filtering applicate on image (a) to year of 1998

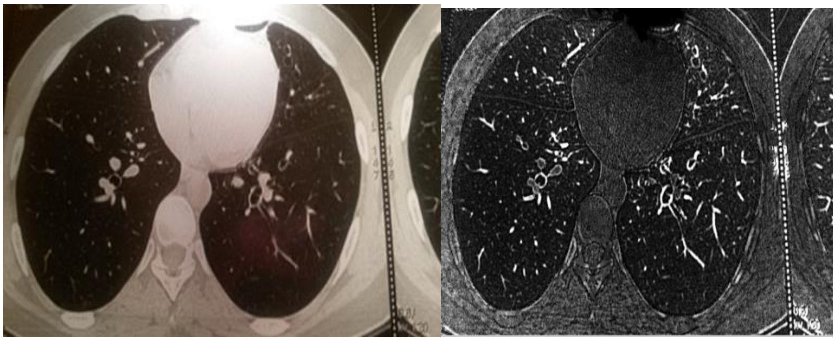
.

Figure .7 illustrated *morphological filtering* applicate on image (d) to year of 2012

In this application, Figure 7 presents the opinions of pulmonologists, indicating that the diagnostic outcome achieved through the proposed method is considered optimal from a clinical perspective.

5.7 Detecting edges in an image

Edge detection is process that typically transforms a *grayscale* image to a binary one , denoting all the pixels belonging to lines of different orientations with instances of 1. The *edge detection* process is widely used and has been tackled using variety of techniques . *Matlab* has an inherent function called edge , which has incorporated most of the popular methods in an easily usable form(George Siogkas, 2013).*Soble* operator is used in image processing techniques particularly in edge detection. The *sobel* operator is based on convolving the image with as all, separable and integer valued filter in horizontal and vertical . (S. Jansi., P. 2012) *figure 8 and 9.*

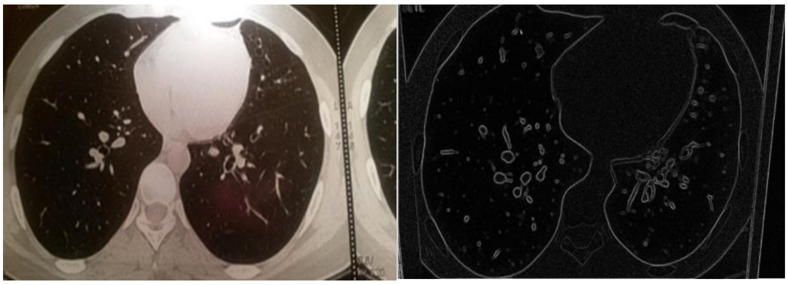


Figure. 8 illustrated image to *soble* detect applicate on image (a) to year of 1998

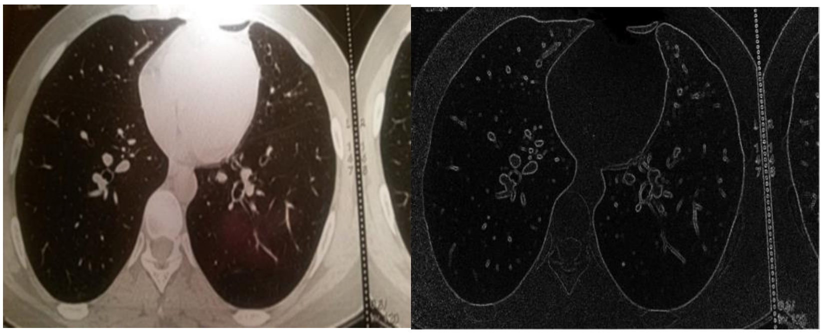


Figure 9 illustrated image to soble detect applicate on image (d) to year of 2012

As demonstrated in Figures 8 and 9, the Sobel edge detection method exhibits limited performance under low brightness conditions. The resulting edges appear weak and poorly defined, indicating that the method may be less effective in enhancing structural features when image illumination is suboptimal..

6. Conclusions

A technique for image improvement is being developed to enhance early disease detection and treatment. This method considers the time factor in identifying abnormalities in target images. The core focus of this research is on image quality and accuracy, incorporating image quality assessment and enhancement techniques. The process involves enhancing grayscale images through morphological filtering, supported by structuring elements (strel). Defects can be easily detected if they have sufficient contrast against the background, utilizing edge detection with the Sobel function.

This study introduces the use of MATLAB for aiding bronchiectasis detection through image processing techniques. Four CT images of the same patient, taken across different years, were analyzed using various MATLAB applications. These processed images were reviewed by pulmonologists, who selected specific methods that effectively highlighted bronchiectatic regions. Notably, adaptive histogram equalization (adapthisteq) enhanced contrast but occasionally exaggerated bronchial cartilage structures bilaterally *(Fig. 5),* potentially altering diagnostic interpretation. In contrast, morphological filtering *(Figs. 6 and 7)* provided clearer delineation of affected areas without distorting anatomical features. The study reflects a personal research initiative and demonstrates the potential of MATLAB-based tools in clinical decision support for respiratory diagnostics.

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