Chapter one
Introduction

1. 1.chest radiograph:

Chest radiograph, colloquially called a chest x-ray (CXR), or chest film, is a projection radiograph of the chest used to diagnose conditions affecting the chest, its contents, and nearby structures. Chest radiographs are among the most common films taken, being diagnostic of many conditions. Like all methods of radiography, chest radiography employs ionizing radiation in the form of X-rays to generate images of the chest. The main radiation dose to an adult from a chest radiograph is around 0.02 mSv (2 mrem) for a front view (PA or posterior-anterior) and 0.08 mSv (8 mrem) for a side view (LL or latero-lateral). (Fred A. Mettler et al, 2008)

Figure (1-1) PA and Lateral views of the chest (Fred A. Mettler et al, 2008)

Chest radiographs are used to diagnose many conditions involving the chest wall, including its bones, and also structures contained within the thoracic cavity including the lungs, heart, and great vessels. Pneumonia and congestive heart failure are very commonly diagnosed by chest radiograph.

For some conditions of the chest, radiography is good for screening but poor for diagnosis. When a condition is suspected based on chest radiography, additional imaging of the chest can be obtained to definitively diagnose the condition or to provide evidence in favor of the diagnosis suggested by initial chest radiography. Unless a fractured rib is suspected of being displaced, and therefore likely to cause damage to the lungs and other tissue structures, x-ray of the chest is not necessary as it will not alter patient management. (Fred A. Mettler et al, 2008)

A chest x-ray can reveal many things inside the body. It can also be used to check the respond to treatment, including:

The condition of lungs. Chest x-ray can detect cancer, infection or air collecting in the space around a lung (pneumothorax). It can also show chronic lung conditions, such as emphysema or cystic fibrosis, as well as complications related to these conditions.

Heart-related lung problems. Chest x-ray can show changes or problems of the lungs that stem from heart problems. For instance, fluid in the lungs (pulmonary edema) can be a result of congestive heart failure.

The size and outline of the heart. Changes in the size and shape of the heart may indicate heart failure, fluid around the heart (pericardial effusion) or heart valve problems.

Blood vessels. Because the outlines of the large vessels near the heart, the aorta and pulmonary arteries and veins are visible on x-rays, they may reveal aortic aneurysms, other blood vessel problems or congenital heart disease.

Calcium deposits. Chest x-ray can detect the presence of calcium in your heart or blood vessels. Its presence may indicate damage to the heart valves, coronary arteries, heart muscle or the protective sac that surrounds the heart. Calcium deposits in the lungs are most often from an old, resolved infection.

Fractures. Rib or spine fractures or other problems with bone may be seen on a chest x-ray.

Postoperative changes. Chest x-ray is useful for monitoring the recovery after making surgery in the chest, such as on the heart, lungs or esophagus. The doctor can look at any lines or tubes that were placed during surgery to check for air leaks and areas of fluid or air buildup.

A pacemaker, defibrillator or catheter. Pacemakers and defibrillators have wires (leads) attached to the heart to make sure that the heart rate and rhythm are normal. Catheters are small tubes used to deliver medications or for dialysis. A chest X-ray usually is taken after placement of such medical devices to make sure everything is positioned correctly.

A chest X-ray produces a black-and-white image of the organs in the chest. Structures that block radiation appear white, and structures that let radiation through appear black. Bones appear white because they are very dense. The heart also appears as a lighter area. Lungs are filled with air and block very little radiation, so they appear as darker areas on the images. (Fred A. Mettler et al, 2013).

1.2. Image processing technique:

These techniques give medical images where they are analysis and enhancement by image processing (Image processing is the study of any algorithm that takes an image as input and returns an image as output) image processing give Image enhancement, noise removal, restoration, feature detection, compression and image analysis give Segmentation, image registration, matching.

Image processing has a major impact on image quality and diagnostic performance of digital chest radiographs. Goals of processing are to reduce the dynamic range of the image data to capture the full range of attenuation differences between lungs and mediastinum, to optimize spatial resolution, to enhance structural contrast, and to suppress image noise. Image processing comprises look-up table operations and spatial filtering. Look-up table operations allow for automated signal normalization and arbitrary choice of image gradation. The most simple and still widely applied spatial filtering algorithms are based on unsharp masking. Various modifications were introduced for dynamic range reduction. More elaborate and more effective are multi-scale frequency processing algorithms. They are based on the subdivision of an image in multiple frequency bands according to its structural composition. This allows for a wide range of image manipulations including a size-independent enhancement of low-contrast structures. (Lippincott Williams and Wilkins, 2003)

1.3. Problem of Study:

Medical images are often deteriorated by noise due to various interferences and other factor associated with imaging process and data acquisition system. Digital images are prone to a variety of types of noise. There are several ways that noise can be introduced into an image, depending on how the image is created. The nature of the physiological system under investigation and procedures used in imaging also diminish the contrast and the visibility of details. Therefore enhancement of the image in respect to the reason of deterioration will make the image diagnosable.

1.4. Objectives:

The main objective of this study is to enhance chest x-ray images using image processing technique.

***Specific Objectives*:**

- To identify the noise in the chest x-ray image.

- To filter the image using spatial filter
- To enhance the image applying histogram equalization
- To find the contrast of the image before and after enhancement and filtering

1.5. Over view of the thesis:

This study falls into five chapters, chapter one, which is an introduction, deals with theoretical frame work of the study and it presents the statement of the study problems, objectives of the study, chapter two deals with radiological physics and back ground (Literature review). Chapter three deal with materials and methods, chapter fours deals with results, chapter five deals with discussion, conclusion, and recommendations.

Chapter Two

Literature Review

2.1. X-ray:

X-ray radiation is of electromagnetic nature; it is a natural part of the electromagnetic spectrum, with a range that includes radio waves, radar and microwaves, infrared, visible and ultraviolet light to X- and γ-rays. (Thorsten M.Buzug, 2008).

2.2.Production of X-ray:

Whenever charged particles (electrons or ions) of sufficient energy hit a material, x-rays are produced.

2.2.1. Production by electrons:

X-rays can be generated by an X-ray tube, a vacuum tube that uses a high voltage to accelerate the electrons released by a hot cathode to a high velocity. The high velocity electrons collide with a metal target, the anode, creating the X-rays. In medical X-ray tubes the target is usually tungsten or a more crack-resistant alloy of rhenium (5%) and tungsten (95%). (Whaites et al, 2002). In medical X-ray tubes the target is usually tungsten or a more crack-resistant alloy of rhenium (5%) and tungsten (95%). (Bushburg et al, 2002).

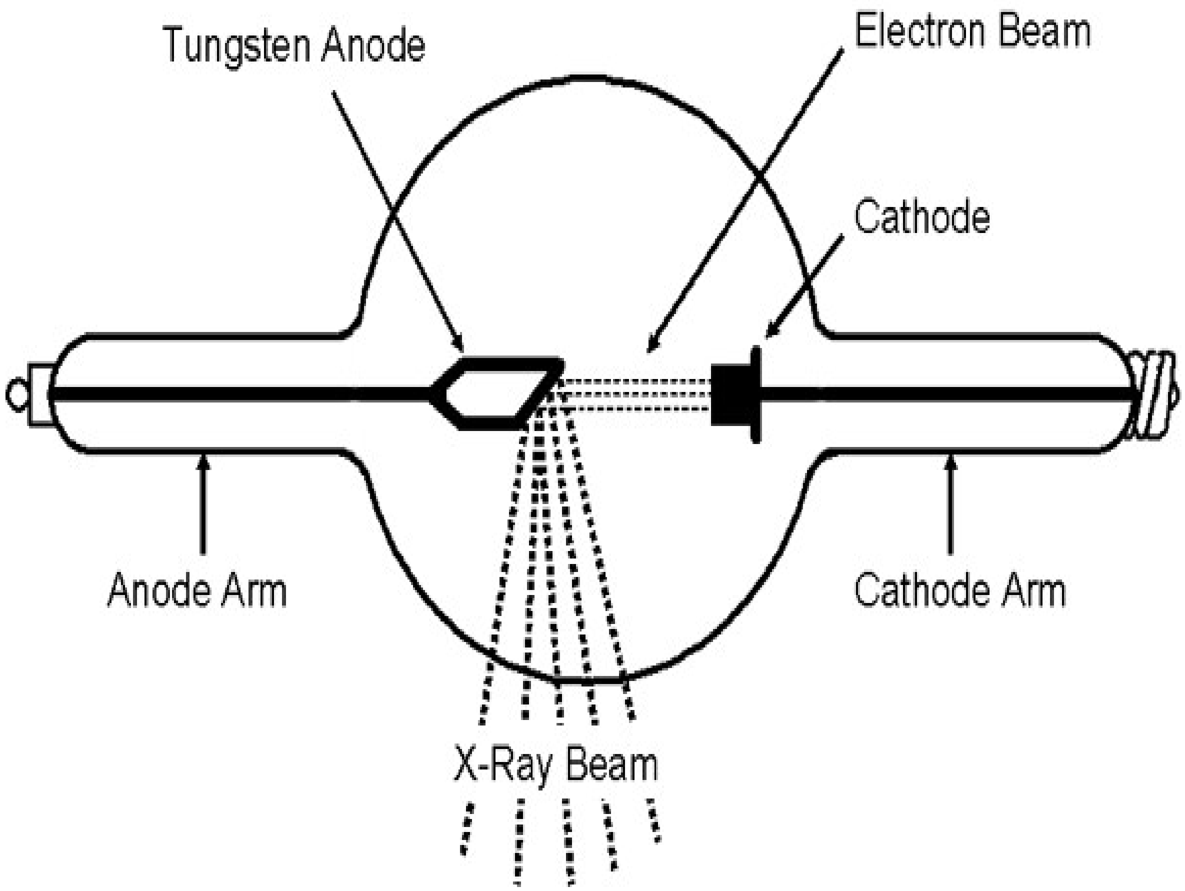

Figure (2-1) X-ray tube (Bushburg et al, 2002)

The maximum energy of the produced X-ray photon is limited by the energy of the incident electron, which is equal to the voltage on the tube times the electron charge, so an 80 kV tube cannot create X-rays with energy greater than 80 keV. When the electrons hit the target, X-rays are created by two different atomic processes:

1. Characteristic X-ray emission: If the electron has enough energy it can knock an orbital electron out of the inner electron shell of a metal atom, and as a result electrons from higher energy levels then fill up the vacancy and X-ray photons are emitted. This process produces an emission spectrum of X-rays at a few discrete frequencies, sometimes referred to as the spectral lines. The spectral lines generated depend on the target (anode) element used and thus are called characteristic lines. Usually these are transitions from upper shells into K shell (called K lines), into L shell (called L lines) and so on.

2. Bremsstrahlung: This is radiation given off by the electrons as they are scattered by the strong electric field near the high-*Z* (proton number) nuclei. These X-rays have a continuous spectrum. The intensity of the X-rays increases linearly with decreasing frequency, from zero at the energy of the incident electrons, the voltage on the X-ray tube.

So the resulting output of a tube consists of a continuous bremsstrahlung spectrum falling off to zero at the tube voltage, plus several spikes at the characteristic lines. The voltages used in diagnostic X-ray tubes range from roughly 20 to 150 kV and thus the highest energies of the X-ray photons range from roughly 20 to 150 keV.(Whaites,2002).

Both of these X-ray production processes are inefficient, with a production efficiency of only about one percent, and hence, to produce a usable flux of X-rays, most of the electric power consumed by the tube is released as waste heat. The X-ray tube must be designed to dissipate this excess heat.

Short nanosecond bursts of X-rays peaking at 15-keV in energy may be reliably produced by peeling pressure-sensitive adhesive tape from its backing in a moderate vacuum. This is likely to be the result of recombination of electrical charges produced by triboelectric charging. The intensity of X-ray triboluminescence is sufficient for it to be used as a source for X-ray imaging. (Camara et al, 2008).

2.2.2. Production by fast positive ions:

X-rays can also be produced by fast protons or other positive ions. The Proton-induced X-ray emission or Particle-induced X-ray emission is widely used as an analytical procedure. For high energies, the production cross section is proportional to $Z_1^2 Z_2^{-4}$, where Z_1 refers to the atomic number of the ion, Z_2 to that of the target atom. (Helmut Paul and Johannes Muhr, 1986).

2.3. The anatomy of the human chest:

The thorax or chest (Greek: θώραξ, Latin: thorax) is a part of the anatomy of humans and various other animals located between the neck and the abdomen. The thorax includes the thoracic cavity and the thoracic wall. It contains organs including the heart, lungs and thymus gland, as well as muscles and various other internal structures. Many diseases may affect the chest, and one of the most common symptoms is chest pain.

In humans and other hominids, the structure of the thorax is the chest region of the body between the neck and the abdomen, along with its internal organs and other contents. It is mostly protected and supported by the rib cage, spine, and shoulder girdle. The contents of the thorax include the heart and lungs and the thymus gland); the (major and minor pectoral muscles, trapezius muscles and neck muscle); internal structures such as the diaphragm, esophagus, trachea and a part of the sternum known as the xiphoid process), as well as the content of the thoracic abdomen (stomach, kidney/adrenal, pancreas, spleen, and lower oesophagus). Arteries and veins are also contained – (aorta, superior vena cava, inferior vena cava and the pulmonary artery); bones (the shoulder socket containing the upper part of the humerus, the scapula, sternum, thoracic portion of the spine, collarbone, and the rib cage and floating ribs).External structures are the nipples. The area exposed by open-necked shirts, the 'V of the chest' is sometimes the location of a light-induced skin disease polymorphous light eruption.

The anatomy of the chest can also be described through the use of anatomical landmarks. The nipple in the male is situated in front of the fourth rib or a little below; vertically it lies a little external to a line drawn down from the middle of the clavicle; in the female it is not so constant. A little below it the lower limit of the great pectoral muscle is seen running upward and outward to the axilla; in the female this is obscured by the breast, which extends from the second to the sixth rib vertically and from the edge of the sternum to the mid-axillary line laterally. The female nipple is surrounded for half an inch by a more or less pigmented disc, the areola. The apex of a normal heart is in the fifth left intercostal space, three and a half inches from the mid-line.

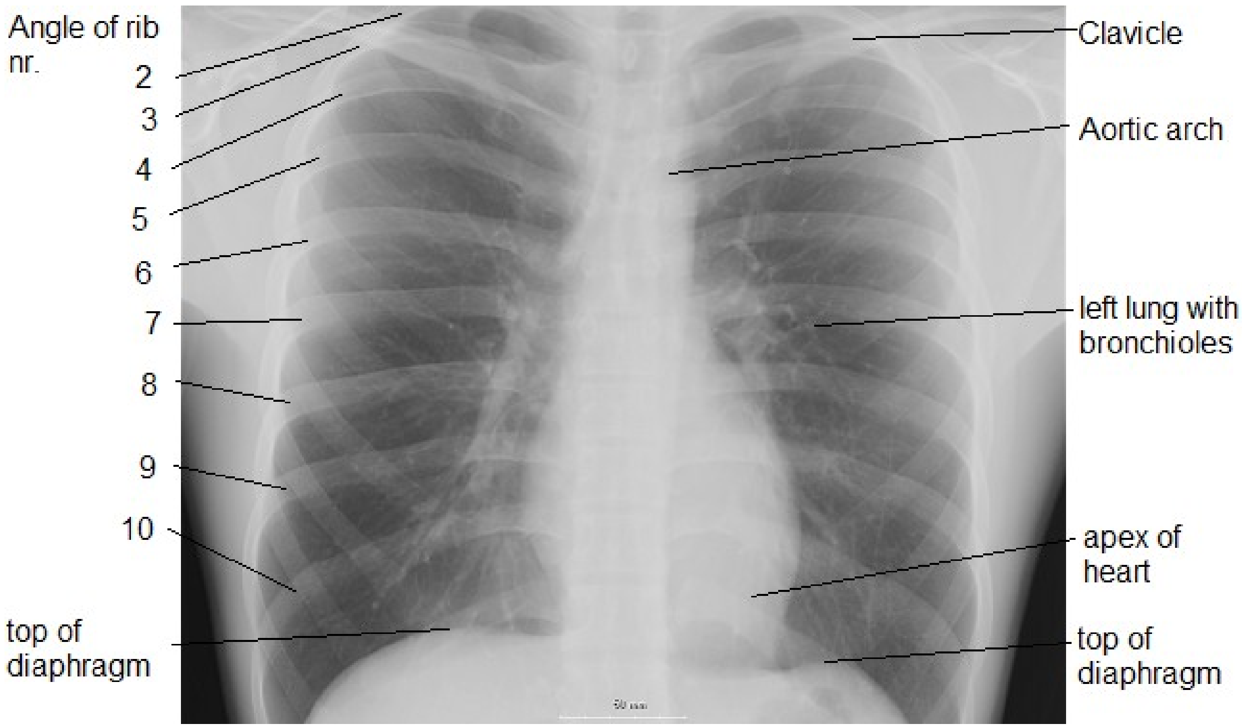

Figure (2.2) An X-ray of a human chest area, with some structures labeled (K.L. Moore and A.M. Agur.2002)

2.4. Image processing:

In imaging science, image processing is any form of signal processing for which the input is an image, such as a photograph or video frame; the output of image processing may be either an image or a set of characteristics or parameters related to the image. Most image-processing techniques involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to it.

Image processing usually refers to digital image processing, but optical and analog image processing also are possible. The acquisition of images (producing the input image in the first place) is referred to as imaging.

Closely related to image processing are computer graphics and computer vision. In computer graphics, images are manually made from physical models of objects, environments, and lighting, instead of being acquired (via imaging devices such as cameras) from natural scenes, as in most animated movies. Computer vision, on the other hand, is often considered high-level image processing out of which a machine/computer/software intends to decipher the physical contents of an image or a sequence of images (e.g., videos or 3D full-body magnetic resonance scans).

In modern sciences and technologies, images also gain much broader scopes due to the ever growing importance of scientific visualization (of often large-scale complex scientific/experimental data). Examples include microarray data in genetic research, or real-time multi-asset portfolio trading in finance. (Tinku Acharya and Ajoy K. Ray, 2005).

2.4.1. Digital images:

Digital images are characterised by matrix size, pixel depth and resolution.

The matrix size

is determined from the number of the columns (m) and the number of rows

(n) of the image

matrix (m×n). The size of a matrix is selected by the operator. Generally, as

the matrix

dimension increases the resolution is getting better (Gonzalez et al., 2009).

Pixel or bit depth refers to the number of bits per pixel that represent the

colour levels of each pixel in an image. Each pixel can take 2k different

values, where k is the bit depth of the image. This means that for an 8-bit image, each pixel can have from 1 to 28 (=256) different colour levels (grey-scale levels). The term resolution of the image refers to the number of pixels per unit length of the image. In digital images the spatial resolution depends on pixel size. The pixel size is calculated by the Field of View (FOV) divided by the number of pixels across the matrix. For a standard
FOV, an increase of the matrix size decreases the pixel size and the ability to see details is
improved. (Lyra, et al, 2011).

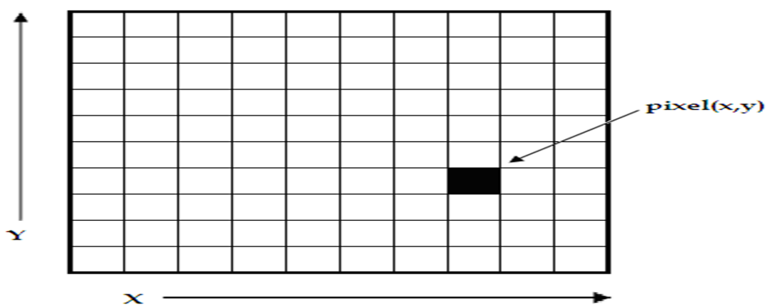

Figure 2-3. A digital image is a 2D array of pixels each pixel is characterized by its (x, y) coordinates and its value (Lyra, et al, 2011).

2.4.2. Types of images in image processing toolbox:

The image types supported from the Image Processing Toolbox from different types.

Binary Images: in these, pixels can only take 0 or 1 value, black or white.

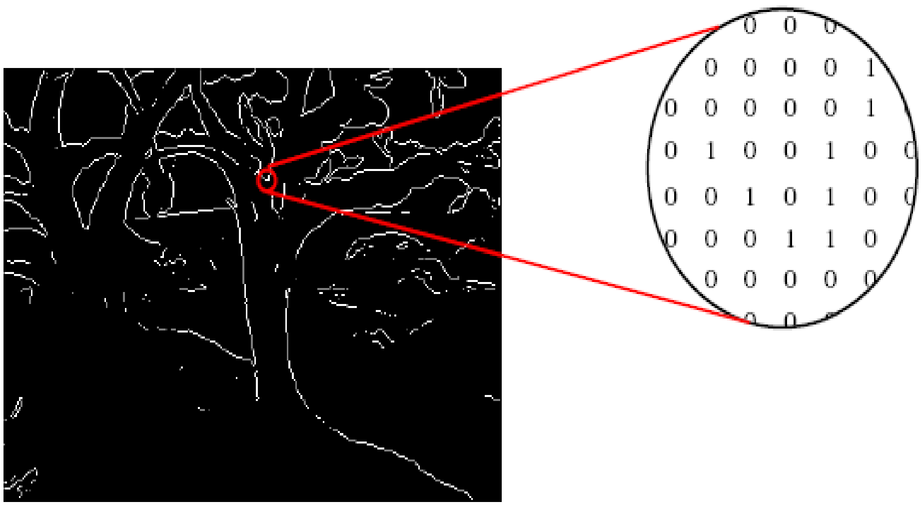

Figure 2-4 Binary image (MathWorks, 2001)

Intensity images: (Grey scale) the image data in a grey scale image represent intensity or brightness. The integers value is within the range of [0…1], where k is the bit depth of the image. For a typical grey scale image each pixel can represented by 8 bits and intensity values are in the range of [0…255], where 0 corresponds to black and 255 to white.

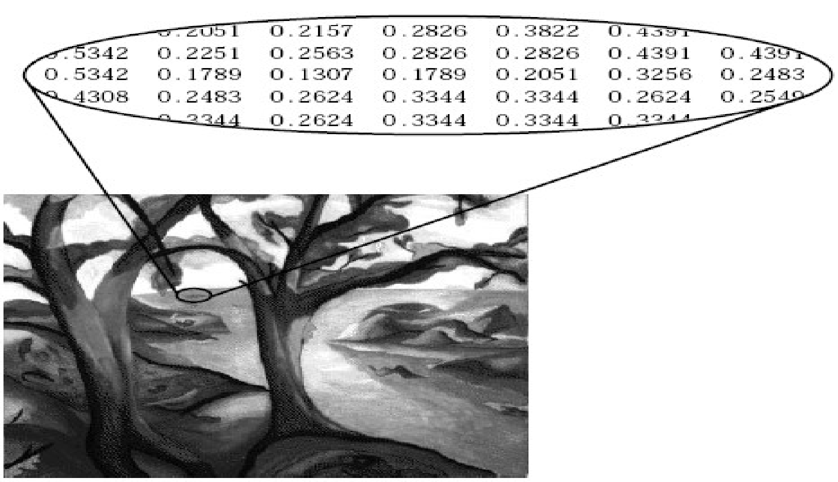

Figure 2-5. Intensity image of class double (MathWorks, 2001)

True color or RGB: in these, an image can be displayed using three matrices, each one corresponding to each of red-green-blue colour. If in an RGB image each component uses 8 bits, then the total number of bits required for each pixel is 3×8=24 and the range of each individual color component is [0…255]

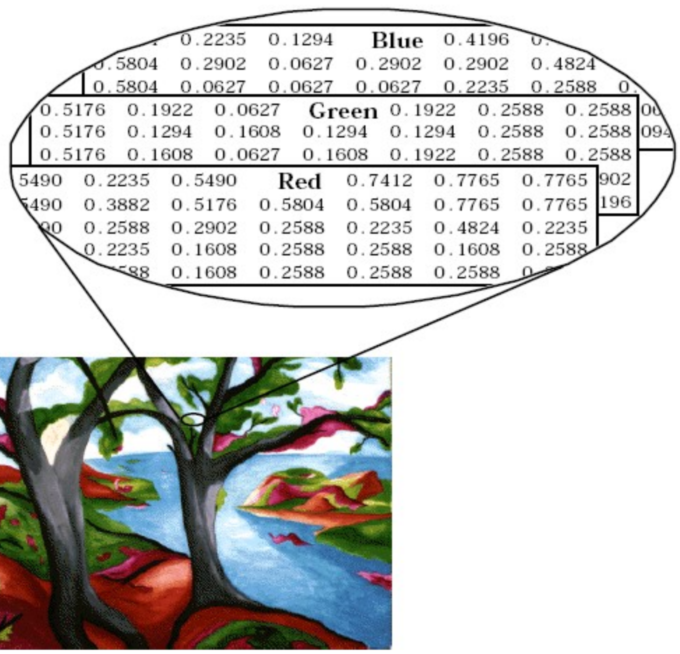

Figure 2-6 RGB image of class double (MathWorks, 2001)

Indexed images: consist of a 2D matrix together with an m×3 colour map (m= the number of the columns in image matrix). Each row of map specifies the red, green, and blue components of a single colour. An indexed image uses direct mapping of pixel values to colour map values. The colour of each image pixel is determined by using the corresponding value of matrix as an index into map. The figure below illustrates the structure of an indexed image. The pixels in the image are represented by integers, which are pointers (indices) to color values stored in the color-map.

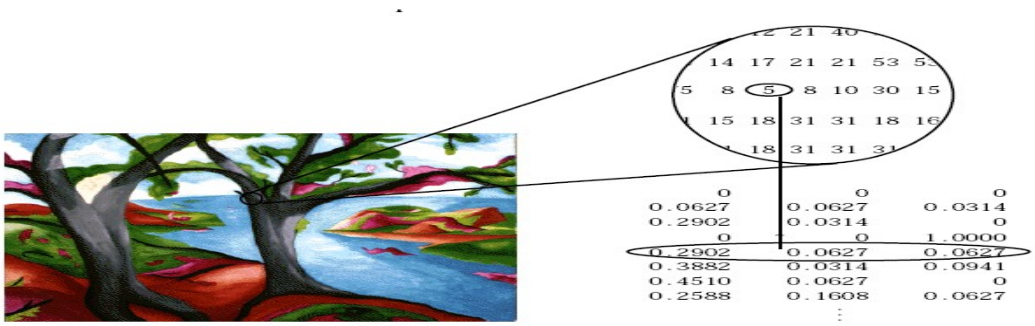

Figure 2-7. Indexed image of class double (MathWorks, 2001)

2.4.3. Digital image processing:

Digital image processing is the use of computer algorithms to perform image processing on digital images. As a subcategory or field of digital signal processing, digital image processing has many advantages over analog image processing. It allows a much wider range of algorithms to be applied to the input data and can avoid problems such as the build-up of noise and signal distortion during processing. Since images are defined over two dimensions (perhaps more) digital image processing may be modeled in the form of multidimensional systems.(Azriel Rosenfeld,1969).

2.4.4. Purpose of Image processing:

The purpose of image processing is divided into 5 groups. They are:

• Visualization - Observe the objects that are not visible.

• Image sharpening and restoration - To create a better image.

• Image retrieval - Seek for the image of interest.

• Measurement of pattern – Measures various objects in an image.

• Image Recognition – Distinguish the objects in an image. (MathWorks, 2001).

2.4.5. Types of methods in Image Processing:

The two types of methods used for image processing are analog and digital image processing. Analog or visual techniques of image processing can be used for the hard copies like printouts and photographs. Image analysts use various fundamentals of interpretation while using these visual techniques. The image processing is not just confined to area that has to be studied but on knowledge of analyst. Association is another important tool in image processing through visual techniques. So analysts apply a combination of personal knowledge and collateral data to image processing.

Digital processing techniques help in manipulation of the digital images by using computers. As raw data from imaging sensors from satellite platform contains deficiencies. To get over such flaws and to get originality of information, it has to undergo various phases of processing. The three general phases that all types of data have to undergo while using digital technique are Pre- processing, enhancement and display, information extraction. (Math Works, 2001).

2.5. IDL in image processing:

IDL (Interactive Data Language) is a high-level programming language that contains an extensive library of image processing and analysis routines. With IDL, image data access is become quickly and begins investigating the best way to extract useful information.

IDL is vectorized, numerical, and interactive, and is commonly used for interactive processing of large amounts of data (including image processing). The syntax includes many constructs from Fortran and some from C.

IDL originated from early VAX/VMS/Fortran, and its syntax still shows its heritage:

```
x = findgen(100)/10
y = sin(x)/x
plot,x,y
```

The findgen function in the above example returns a one-dimensional array of floating point numbers, with values equal to a series of integers starting at 0.

2.5.1. Features:

As a computer language, IDL:

Is dynamically typed.

Has separate namespaces for variables, functions and procedures, but no namespace hierarchy.

Was originally single threaded but now has many multi-threaded functions and procedures.

Has all function arguments passed by reference; but see "problems", below.

Has named parameters called keywords which are passed by reference.

Provides named parameter inheritance in nested routine calls, by reference or value.

Does not require variables to be predeclared.

Provides common block declarations and system variables to share global values among routines.

Provides a basic form of object-oriented programming, somewhat similar to Smalltalk, along with operator overloading.

Implements a persistent, global heap of pointer and object variables, using reference counting for garbage collection.

Compiles to an interpreted, stack-based intermediate p-code (à la Java Virtual Machine).

Provides simple and efficient index slice syntax to extract data from large arrays.

Provides various integer sizes, as well as single and double precision floating point real and complex numbers.

Provides composite data types such as character strings, homogeneous-type arrays, lists, hash tables, and simple (non-hierarchical) record structures of mixed data types.

2.6. Previous studies:

In reviewing of literature in locally and internationally there are some published studies regarding the enhancement of chest x-ray by many researchers who they are mentioned below:

Sarage and Jambhorkar **(**2012) enhanced chest X-Ray images using Filtering Techniques**,** in their study x-ray image does not represent the correct representation of the object under observation; it was always ruined by degradations during acquisition and within the imaging system itself. These include noise, blurring and distortion. Noise removal was an important and challenging issue in medical image processing. Various filtering techniques had been developed to solve the noise removal problems, but most of them required deep expert knowledge to design appropriate image filters. These filtering techniques had their own assumptions, advantages and disadvantages. In their paper they were propose mean and median filtering techniques for the removal of noise from the X-ray medical image. Proposed method applied for noise removal problems. In terms of statistical quantity measures such as MSE, RMSE, PSNR, AD, their results showed the superiority of the proposed method.

S.K.Mahendran, S.Santhosh Baboo (2011) enhanced tibia fracture detection tool using image processing and classification fusion techniques in X-ray images; in their study Automatic detection of fractures from x-ray images was considered as an important process in medical image analysis by both orthopaedic and radiologic point of view. Their paper proposes a fusion-classification technique for automatic fracture detection from long bones, in particular the leg bones (Tibia bones). The proposed system has four steps, namely, preprocessing, segmentation, feature extraction and bone detect ion, which used an amalgamation of image processing techniques for successful detection of fractures. Three classifiers, Feed Forward Back Propagation Neural Networks (BPNN), Support Vector Machine Classifiers (SVM) and Naïve Bayes Classifiers (NB) were used during fusion classification. The results from various experiments proved that the proposed system was showed significant improvement in terms of detection rate and speed of classification.

Dr. Krishna Mohanta and Dr.V.Khanaa (2013), An efficient contrast enhancement of medical X-ray images –adaptive region growing approach**,** In digital image processing medical imaging was one of the most significant application areas. For visualizing and extracting more details from the given image processing of medical images was much more supportive. Several techniques were existence nowadays for enhancing the quality of medical image. Contrast enhancement was one of the most functional methods for the enhancement of medical images. Various contrast enhancement techniques were in practice, some were as follows: linear stretch, histogram equalization, convolution mask enhancement, region based enhancement, adaptive enhancement was already available. Based on characteristics of image choices could be done. On comparing their approach with the existing popular approaches of adaptive enhancement and linear stretching, it had been concluded that the proposed technique was given much better results than the existing ones. Further, the technique was seed dependent so selection of seed was very important in this algorithm. A seed chosen in darker regions would gave better results than the seed chosen in brighter region, because it was assumed that user would required enhancing the darker portions of the image. Furthermore, zooming window and edge growing method was used to visualize the edges more precisely which gave an added advantage was to doctors for better perception of x-ray.

Ali Abid D. AL-Zuky et al (2009) hybrid contrast enhancement for X-ray images**,** the applications of x-ray were highly increased for different medical and industrial proposes. But the x-ray images always very dark and with low contrast. The digital image enhancement techniques had become a major process for extracting information from the sample structure and make the interpretation of these images easier. So, in their study they were used two enhancement techniques to improve x-ray image appearance and contrast. The first, method was the sliding histogram operations, and the second, method was the histogram equalization, these used to improved dynamic image range and improved contrast image quality. The results showed that the x-ray image quality enhanced and image contrast highly increased by using these methods, especially histogram equalization.

Hariharan, S et al (2000) an algorithm for the enhancement of chest X-ray images of tuberculosis patients, radiographic images were most commonly used by physicians all over the world, for preliminary diagnosis of the disease in the medical field. This is because X-ray procedures were simple and relatively inexpensive, as compared to other imaging modalities such as MRI. However X-ray films were noisy and difficult to read even for the experienced radiologists and physicians. Hence it was necessary to developed suitable processing techniques in order to help physicians and radiologists for diagnosis of disease. In their paper they were propose an algorithm for enhancement of chest X-ray images of TB patients for better diagnosis of the disease.

I.C. Mehta et al (2006) analysis and review of chest radiograph enhancement techniques; chest radiograph inherently displayed wide dynamic range of x ray intensities. Wide variety of preprocessing procedures for chest radiograph based on local equalization, sharpening, fuzzy set, neural network and combination of modification of these techniques had been proposed. In their paper they have made analysis of twelve different techniques specifically derived and tested for enhancement of chest x ray giving brief details of working of algorithm. Radiology department were staring used central system to stored digital chest radiograph. This provided opportunity to used chest workstation with different enhancement algorithm that ran in background and radiologist may view a patient radiograph using different enhancement algorithm for subsequent analysis. Enhancement algorithm should be selected based on radiologist requirement and disease specific. Hence it is necessary to make review and analysis of available chest radiograph enhancement technique.

Manoj R. Tarambale and Nitin S. Lingayat (2013) spatial domain enhancement techniques for detection of lung tumor from chest X-ray image, Advances in the area of bio-medical image processing of chest X-ray had resulted in the acquisition of high-quality images of the human chest. With these advances, there arises a genuine need for image processing algorithms specific to the chest, in order to fully exploit this digital technology. Image enhancement was an important part of image processing and it was applied in every field where images were ought to be understood and analyzed. Image enhancement was basically improved the interpretability or perception of information in images for human viewers and providing better input for other automated image processing techniques. The principal objective of image enhancement was to modified attributes of an image to make it more suitable for a given task and a specific observer. During this process, one or more attributes of the image are modified. In image enhancement,

resizing, improving brightness and contrast of the image, filtering was done. The enhancement process improved the visual quality of the image by removed extraneous information from the image. Their paper was focus on spatial domain techniques for image enhancement, with particular reference to point processing methods and histogram processing.

Lijun Yin et al (2003) Scalable edge enhancement with automatic optimization for digital radiographic images, the ability to resolve fine picture detail was of paramount importance in medical imaging systems for viewing small tissue, bone structure and anatomy in X-ray images. In their paper, they presented a new digital radiographic image processing system with the property of scalability and adaptability. A new automatic optimization algorithm is proposed for display, an adaptive detection of a region-of-interest is developed, and a “scalable edge enhancement algorithm” was proposed to improved the image quality for showing subtle structures in digital radiographic images. The advantage of the proposed method is demonstrated through experiments on 200 digital X-ray images and 50 CT images, in which different parts of human body structures are captured.

R.Senthilkumar, Dr. M. Senthilmurugan (2014) triad histogram to enhance chest x-ray image, and the objective of digital image processing (DIP) referred to manipulate and enhanced the image quality. There were plenty of image processing applications and problems were there, namely image representation enhancement, restoration and compression ...etc. In their paper, only three types of histogram modification methods (i.e. HE, AHE, & CLAHE) were discussed and implemented in matlab. The performance of these techniques was then compared using various parameters such as peak signal to noise ratio (PSNR), mean squared error (MSE), signal to noise ratio (SNR), absolute mean brightness error (AMBE) and entropy. The results showed that CLAHE is efficient when compared to other two methods.

Dr. Khalil I. Jassam (2005), Image processing of conventional x-ray images, the goal of their paper was to outline the procedure of obtaining sharper and more visible images from a rejected X-ray. This process will improved X-ray image quality and produce image data that was more effectively displayed for a later visual imaging diagnosis. Image processing enhances image contrast thus increased image visibility, helping both physicians and radiologists to make more accurate diagnoses and to decrease the need to retake X-rays. This in turn reduced the risk of radiation exposure and increases economical benefits by lessening the number of rejected X-rays. Different spectral and spatial enhancement techniques were used both in the spatial and frequency domain. The obtained X-ray images are sharper, more visible and recognizable, and provide much more information.

R. B. Tiwari et al (2007) Dental x-ray image enhancement based on human visual system and local image statistics, X-ray clinical medical image generally suffers from low contrast quality and degradations which vary from one region to another. Extraction of features in medical science and image processing was a matter of study and research. X-rays contain high redundancy, as far as background information was considered and in a way govern local image statistics. Contrast enhancement techniques based on visual perception criterion, deal in used of

local (3x3) edge operators for computation of local image statistics of non-filtered images for contrast modification. In context to their earlier work and findings in, they suggested the use of LoG filter for contrast improvement process in place of methods discussed in .An adaptive technique was suggested to improve the contrast quality of dental X-ray image using the Laplacian-of-a-Gaussian (LoG) Filter.

Biologically, LoG Filter has a similar profile to the response of the receptive fields in the human visual system (HVS). Here, the results obtained reveal that LoG Filter is the best choice, whose standard deviation parameter sigma ‘s’ can be conveniently used to tune the pixel value to a maximum gray value of 255.000000 and a minimum gray value of 0.000000 in their process of contrast modification. A description, an implementation, an estimate of the contrast gain and comparison of performance of various edge detectors was presented. Implementation of LoG Filter serves to be the best choice in the process of contrast modification and achieve high contrast gain.

Fatemeh Shahsavari Alavijeh and Homayoun Mahdavi-Nasab **(**2015) Multi-scale morphological image enhancement of chest radiographs by a hybrid scheme, Chest radiography was a common diagnostic imaging test, which contains an enormous amount of information about a patient. However, its interpretation was highly challenging. The accuracy of the diagnostic process was greatly influenced by image processing algorithms; hence enhancement of the images was indispensable in order to improve visibility of the details. Their paper aims at improving radiograph parameters such as contrast, sharpness, noise level, and brightness to enhance chest radiographs, making use of a triangulation method. Here, contrast limited adaptive histogram equalization technique and noise suppression were simultaneously performed in wavelet domain in a new scheme, followed by morphological top-hat and bottom-hat filtering. unique implementation of morphological filters allows for adjustment of the image brightness and significant enhancement of the contrast. Their proposed method was tested on chest radiographs from Japanese society of radiological technology database. The results were compared with conventional enhancement techniques such as histogram equalization, contrast limited adaptive histogram equalization, retinex, and some recently proposed methods to show its strengths. The experimental results revealed that the proposed method can remarkably improve the image contrast while keeping the sensitive chest tissue information so that radiologists might have a more precise interpretation.

Chapter Three

Materials and methods

3.1. Materials:

3.1.1. Equipments:

- Personal Computer (PC)
- IDL program
- X-ray

3.2. Study population:

Total of 50 patients examined chest x-ray were from both gender male and females and they were adults, the images are taken for different reasons.

3.3. Place and duration of the Study:

This study conducted in Sudan University College of Radiology during the period from December 2014 to May 2015.

3.4. Sampling and type:

Total of 50 patients examined chest x-ray in diagnostic department in Modern Medical Center, the images which are taken was CR images.

3.5. Method of data Collection:

The total of 50 patients have underwent to chest x-ray it will be collected in Modern Medical Center. Then enhancement of the data by using image processing technique.

3.6. Method of data analysis:

Histogram equalization:

The histogram of an image shows the number of pixels for each pixel value within the range of the image. Peaks in the histogram represent more common values within the image that usually consist of nearly uniform regions. Valleys in the histogram represent less common values. Empty regions within the histogram indicate that no pixels within the image contain those values.

The following figure shows an example of a histogram and its related image.

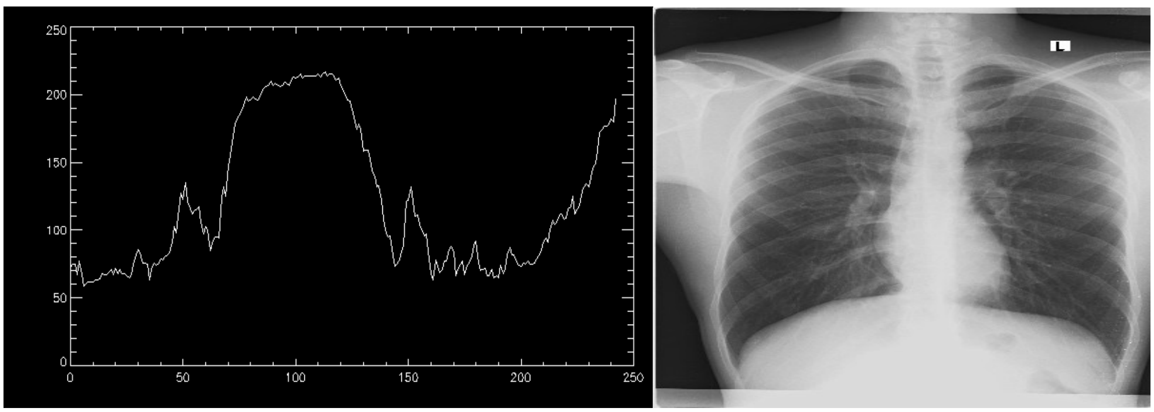

Figure 3-1: ***Example of a Histogram (left) and Its Related Image (right)***

The contrast of these variations can be increased by equalizing the image's histogram. During histogram equalization, the values occurring in the empty regions of the histogram are redistributed equally among the peaks and valleys. This process creates intensity gradients within these regions (replacing nearly uniform values), thus highlighting minor variations.

Equalizing with Histograms:

The HIST_EQUAL function can use to perform basic histogram equalization within IDL. Unlike histogram equalization methods performed on color tables, the HIST_EQUAL function results in a modified image, which has a different histogram than the original image. The resulting image shows more variations (increased contrast) within uniform areas than the original image. The following example applies histogram equalization to the pervious chest x-ray image in figure 3-1

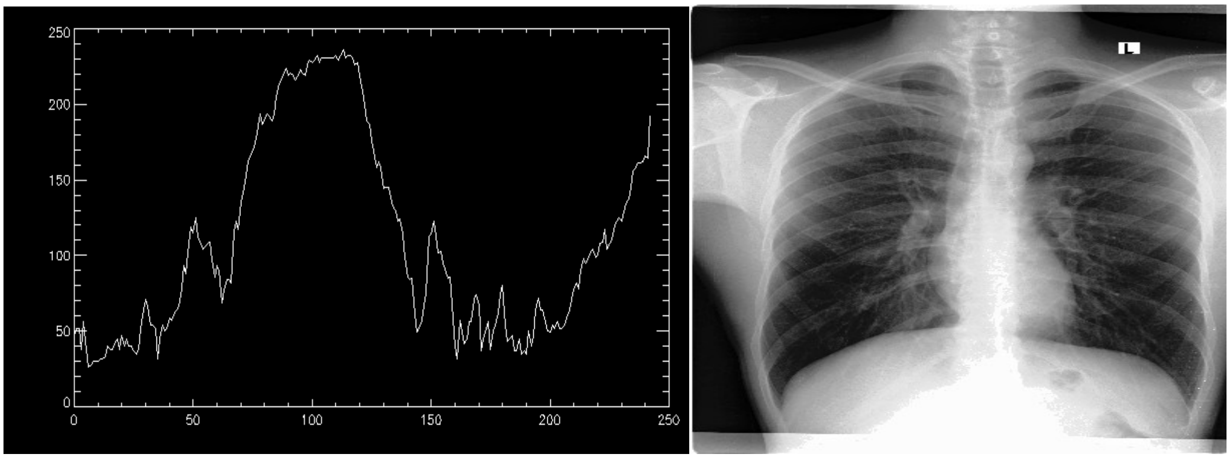

Figure 3-2 histogram of the equalized chest x-ray image and its equalized chest x-ray image for the pervious example

Subject contrast:

Subject contrast is the difference in some aspect of the signal, prior to its being recorded. Subject contrast can be a consequence of a difference in intensity, energy fluence, x-ray energy, phase, radionuclide activity, relaxation characteristics, and so on. The subject contrast (C_s) can be defined as:

$$\mathbf{C}_s = \frac{A-B}{A} \qquad (3\text{-}1)$$

Where A is the intensity of the lung area, B is the intensity of the mediastinum area and because A > B, C, will be a number between 0.0 and 1.0. (*Jerrold T. Bushberg et al 2002*).

Quantum noise:

The term quantum is defined as "something that may be counted or measured," and in medical imaging quanta is a generic term for signals that come in individual, discrete packets. For a digital x-ray detector system with square pixels (as a simple example), if the average number of x-rays recorded in each pixel is *N,* then the noise (per pixel) will be

$$\sigma = \sqrt{N} \qquad (3\text{-}2)$$

Where σ is called the standard deviation or the noise and N is the average number of x-rays recorded in each pixel.

$$SNR = \frac{N}{\sigma} = \frac{N}{\sqrt{N}} = \sqrt{N} \qquad (3\text{-}3)$$

Where SNR is the signal to noise ratio. (Jerrold *T.* Bushberg et al 2002).

Filter:

Filtering in image processing is a process that cleans up appearances and allows for selective highlighting of specific information. Noise is basically considered as a high pass region. Noises which are commonly found in any image are Gaussian noise and salt & pepper noise. (Fabrizio Russo, 2002).

Mean filter:

Mean filtering is a simple, it is a spatial domain filter used for noise reduction in images, intuitive and easy to implement method of *smoothing* images, *i.e.* reducing the amount of intensity variation between one pixel and the next. The idea of mean filtering is simply to replace each pixel value in an image with the mean (`average') value of its neighbors, including itself. This has the effect of eliminating pixel values which are unrepresentative of their surroundings. Mean filtering is usually thought of as a convolution filter. Like other convolutions it is based around a kernel, which represents the shape and size of the neighborhood to be sampled when calculating the mean. Often a 3×3 square kernel is used, as shown in figure below

$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$
$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$
$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$

Figure (3-3) ***3×3 averaging kernel often used in mean filtering***

Computing the straightforward convolution of an image with this kernel carries out the mean filtering process. (Robert Fisher et al 2000).

Chapter four

Results

The results of this study consisted of: noise before and after enhancement, noise before and after filter enhancement, signal before and after enhancement, signal before and after filter enhancement, signal to noise ratio before and after enhancement, signal to noise ratio before and after filter enhancement, contrast before and after enhancement, and contrast before and after filter enhancement.

Chest x-ray before enhancement

Chest x-ray after enhancement

Figure 4-1 shows chest x-ray image before and after enhancement

(A)

(B)

Figure 4-2 scatter plot of the noise in chest x-ray image before and after enhancement (A) in high intensity area, (B) in low intensity area

Item	Mean±STD
Noise in high intensity area before enhancement	5.18323±3.07525
Noise in low intensity area before enhancement	1.70899±1.2956
Noise in high intensity area after enhancement	11.0518±2.88455
Noise in low intensity area after enhancement	3.14251±1.66667

Table 4-1 shows the mean and standard deviation for the noise in high intensity area and low intensity area before and after enhancement

(C)

(D)

Figure 4-3 scatter plot of the noise in chest x-ray image before and after filter enhancement (C) in high intensity area, (D) in low intensity area

Item	Mean±STD
Noise in high intensity area before filter enhancement	3.37592±3.0817392
Noise in low intensity area before filter enhancement	1.22766±3.713

	954
Noise in high intensity area after filter enhancement	2.9947±4.0720324
Noise in low intensity area after filter enhancement	1.75662±3.44051536

Table 4-2 shows the mean and standard deviation for the noise in high intensity area and low intensity area before and after filter enhancement

(E)

(F)

Figure 4-4 scatter plot of the signal before and after enhancement (E) in high intensity area, (F) in low intensity area

Item	**Mean±STD**
Signal in high intensity area before enhancement	7367±4326
Signal in low intensity area before enhancement	1685±962
Signal in high intensity area after enhancement	6678±4654
Signal in low intensity area after enhancement	980±123

Table 4-3 shows the mean and standard deviation for the signal in high intensity area and low intensity area before and after enhancement.

(G)

(H)

Figure 4-5 scatter plot of the signal before and after filter enhancement (G) in high intensity area, (H) in low intensity area

Item	**Mean±STD**
Signal in high intensity area before filter enhancement	7382±4196
Signal in low intensity area before filter enhancement	1630±1275
Signal in high intensity area after filter enhancement	6677±4538
Signal in low intensity area after filter enhancement	950±468

Table 4-4 shows the mean and standard deviation for the signal in high intensity area and low intensity area before and after filter enhancement.

(I)

(J)

Figure 4-6 scatter plot of the signal to noise ratio in chest x-ray image before and after enhancement (I) in high intensity area, (J) in low intensity area

Item	**Mean±STD**
SNR in high intensity area before enhancement	1421.31±1406.72
SNR in low intensity area before enhancement	536.195 ±577.2
SNR in high intensity area after enhancement	604.244±1613.42
SNR in low intensity area after enhancement	573.439±94.9369

Table 4-5 shows the mean and standard deviation for the signal to noise ratio in high intensity area and low intensity area before and after enhancement.

(K)

(L)

Figure 4-7 scatter plot of the signal to noise ratio in chest x-ray image before and after filter enhancement (K) in high intensity area, (L) in low intensity area

Item	**Mean±STD**
SNR in high intensity area before filter enhancement	2264.65±1242.92

SNR in low intensity area before filter enhancement	511.648±1038.56
SNR in high intensity area after filter enhancement	1018.92±1515.34
SNR in low intensity area after filter enhancement	577.982±266.421

Table 4-6 shows the mean and standard deviation for the signal to noise ratio in high intensity area and low intensity area before and after filter enhancement.

(M)

Figure 4-8 scatter plot of the contrast in chest x-ray image before and after enhancement (M)

Item	**Mean±STD**
Contrast before enhancement	0.78±0.05965091 1
Contrast after enhancement	0.97±0.075415 429

Table 4-7 shows the mean and standard deviation for contrast before and after enhancement

(N)

Figure 4-9 scatter plot of the contrast in chest x-ray image before and after filter enhancement (N)

Item	Mean±STD
Contrast before filter enhancement	0.70±0.0529 97983
Contrast after filter enhancement	0.90±0.073 33525

Table 4-8 shows the mean and standard deviation for contrast before and after filter enhancement

Chapter five
Discussion, Conclusion and Recommendations

This study was aimed to enhance chest x-ray images using image processing technique, the study was done in Modern Medical Center, and 50 chest x-ray images were processed using IDL with details as follows: In this study data analyzed by using IDL program to enhance the contrast within the bones and lung, reduce the noise, filter the images and find signal to noise ratio. The technique used for this study was histogram equalization and mean filter.

5.1. Discussion:

The results of this study as shown In Figure (4-1) and table (4-1) the amount of the noise before and after enhancement by histogram equalization was 5.2±3.1 and 11.1±2.9 respectively for high intensity area. This mean the enhancement increase the amount of noise by 1 per1.271 for every 1 unit from x axis which should be filtered before and after enhancement. In case of low intensity area the amount of the noise before and after enhancement by histogram equalization was 1.70899±1.2956 and 3.14251±1.66667 respectively, this mean the enhancement increase the amount of noise by 1 per 0.660 for every 1 unit from x axis.

The amount of the noise before and after filter enhancement by histogram equalization was 3.37592±3.0817392 and 2.9947±4.0720324 respectively in Figure (4-2) and table (4-2) for high intensity area. This mean the enhancement with filter decrease the amount of noise by 1 per 1.296 for every 1 unit from x axis. In case of low intensity area the amount of the noise before and after filter enhancement by histogram equalization was 1.22766±3.713954 and 1.75662±3.44051536 respectively, this mean the enhancement decrease the amount of noise by 1 per 0.856 for every 1 unit from x axis.

The amount of the signal before and after enhancement by histogram equalization was 7367±4326 and 6678±4654 respectively in Figure (4-3) and table (4-3) for high intensity area. This mean the enhancement decrease the amount of signal by 1 per1.296 for every 1 unit from x axis. In case of low intensity area the amount of the signal before and after enhancement by histogram equalization was 1685±962 and 980±123 respectively, this mean the enhancement decrease the amount of signal by 1 per 0.723 for every 1 unit from x axis.

The amount of the signal before and after filter enhancement by histogram equalization was 7382±4196 and 6677±4538 respectively in Figure (4-4) and table (4-4) for high intensity area. This mean the enhancement decrease the amount of signal by 1 per1.31for every 1 unit from x axis. In case of low intensity area the amount of the signal before and after filter enhancement by histogram equalization was 1630±1275 and 950±468 respectively, this mean the enhancement decrease the amount of signal by 1 per 0.664 for every 1 unit from x axis.

The amount of the signal to noise ratio before and after enhancement by histogram equalization was 1421.31±1406.72 and 604.244±1613.42 respectively in Figure (4-5) and table (4-5) for high intensity area. This mean the enhancement increase the amount of the signal to noise ratio by 1 per 0.455 for every 1 unit from x axis. In case of low intensity area the amount of the signal to noise ratio before and after enhancement by histogram equalization was 536.195±577.2 and 573.439±94.9369 respectively, this mean the enhancement increase the amount of the signal to noise ratio by 1 per 0.731 for every 1 unit from x axis.

The amount of the signal to noise ratio before and after filter enhancement by histogram equalization was 2264.65±1242.92 and 1018.92±1515.34 respectively in Figure (4-6) and table (4-6) for high intensity area. This mean the enhancement decrease the amount of signal to noise ratio by 1 per1.017 for every 1 unit from x axis. In case of low intensity area the amount of the signal to noise ratio before and after filter enhancement by histogram equalization was 511.648±1038.56 and 577.982±266.421 respectively, this mean the enhancement increase the amount of signal to noise ratio by 1 per 0.499 for every 1 unit from x axis.

The amount of the contrast before and after enhancement by histogram equalization was 0.78±0.059650911 and 0.97±0.075415429 respectively in Figure (4-7) and table (4-7). This mean the enhancement increase the amount of the contrast by 1 per 0.597 for every 1 unit from x axis. In figure (4-8) and table (4-8) the amount of the contrast before and after filter enhancement by histogram equalization was0.70±0.052997983 and 0.90±0.07333525 respectively. This mean the enhancement increase the amount of the contrast by 1 per 0.419 for every 1 unit from x axis.

The results of this study was agreed to (Sarage and Jambhorkar , 2012), they were used mean filter and after applied it to the images, it showed that there was significant reduction in noise, also this same technique was used by (by Manoj R. Tarambale and Nitin S. Lingayat, 2013) and they were obtained for the similar results as mentioned above. In addition the results of (Ali Abid D. AL-Zuky et al 2009) and (Dr. Krishna Mohanta and Dr.V.Khanaa 2013) showed that the histogram equalization has a good ability to produce an image with high contrast (i.e.) increase the visibility of the hidden region like edge and the small structures, as well as to composite the image brightness and produce more sensible view.

5.2. Conclusion

We conclude from this study that IDL program techniques such as histogram equalization which was used to enhanced the contrast of the images in the presence of noise, and filtering the images using mean filter which were performed to reduce the noise in chest x images cause the noise reduced the quality of the image and visibility of the details. The results showed the efficiency of these techniques to improve and boost the quality of the images in terms of contrast, the contrast was significantly increased and it was the mean before enhancement 0.78 and it became after enhancement 0.97, noise which it was the mean before enhancement 5.18323 and it was reduced significantly after used the mean filter to 3.37592, signal and signal to noise ratio.

5.3. Recommendation:

- The technologist should train to handle images in order to produce images with high efficiency.
- Image enhancement is basically improving the interpretability or perception of information in images and it is important to develop image enhancement program after obtained images.
- Similar study can be done for different organs such as dental, bone and so on.

References

Mettler FA, 2013, Essentials of Radiology. 3rd ed. Philadelphia, Pa.: Saunders Elsevier.

Fred AM, Walter HTT and Yoshizumi, MM, 2008: "Effective Doses in Radiology and Diagnostic Nuclear Medicine: A Catalog" - Radiology; 248:254–263 .

Bushburg, Jerrold; Anthony Seibert; Edwin Leidholdt; John Boone (2003). The Essential Physics of Medical Imaging. USA: Lippincott Williams & Wilkins. p. 116. ISBN 0-683-30118-7.

Thorsten M. Buzug.2008.Computed tomography:from photon statistics is to modern cone-Beam CT,ISBN 3540394079

Whaites E; Roderick C (2002). Essentials of Dental Radiography and Radiolog***y***. Elsevier Health Sciences. pp. 15–20. ISBN 0-443-07027-X.

Camara, C. G.; Escobar, J. V.; Hird, J. R.; Putterman, S. J. (2008). "Correlation between nanosecond X-ray flashes and stick–slip friction in peeling tape". Nature 455 (7216): 1089–1092. Bibcode:2008 Nature.455.1089C. Doi: 10.1038/nature07378. Retrieved 2 February 2013.

Helmut Paul and Johannes Muhr, 1986, Physics Reports 135 pp. 47-97.

K.L. Moore & A.M. Agur. Lippincott, 2002, Chest.png and Essential Clinical Anatomy, 2 ed.

Tinku Acharya, Ajoy K. Ray, 2005, Image Processing: Principles and Applications, ISBN 10-0471745782, 13-9780471745785,in USA.

Gonzalez, R.; Woods, R., & Eddins, S., 2009, Digital Image Processing using MATLAB, second edition, Gatesmark Publishing, United States of America, ISBN 9780982085400.

MathWorks Inc, 2001, Image Processing Toolbox ® User's Guide, the MathWorks Inc, United States of America.

Azriel Rosenfeld 1969, Picture Processing by Computer, New York: Academic Press,

Fabrizio Russo, 2002, "An Image Enhancement Technique Combining Sharpening and Noise Reduction", IEEE Transactions on Instrumentation and Measurement, vol. 51, no. 4, August

Robert Fisher, Simon Perkins, Ashley Walker and Erik Wolfart 2000, Hypermedia Image Processing Reference.ISBN 0471962434