Chapter One

Introduction

Image enhancement techniques are used to improve the interpretability or perception of information in images for human viewers, or to provide `better' input for other automated image processing techniques. Image enhancement allow the observer able to see details in image that may not be immediately observable in the origin image , this may be the case, for example, when the dynamic range of data and that of display are not commensurate, when the image has high level of noise or when contrast is in sufficient. It also allows the observable to see details in the image that may not be immediately observable in the original image. This may be the case, for example, when the dynamic range of the data and that of the display commensurate, when the image has high level of the noise or when contrast is insufficient, Graaf (1988). it is the transformation or mapping of one image to another, this transformation is not necessary one-to-one, so that two different input image transform into the same or similar output image after enhancement .It is involves taking an image and improving it visually, typically by taking advantages of human visual systems responses. One of the simples enhancement techniques is to simply stretch the contrast of an image enhancement methods tend to be specific problem ,for example, a method is used to enhance satellite images may not suitable for enhanced medical images, Niblack (1986).

The basic goal of image enhancement is to process the image so that we can view and assess the visual information it contains with greater clarity, image enhancement, therefore, is rather subjective because it depends strongly on the specific information the user is hoping to extract from the image. The primary condition for image enhancement is that the information that you want to extract, emphasize or restore must exist in the image. Enhancement

algorithm play a critical role in choosing an algorithms for real -time applications despite the effectiveness of each of these algorithms when applied separately ' in practice when has to device a combination of such methods to achieve more effective image enhancement. Use image enhancement techniques as pre- processing tools for other image processing techniques' then quantities measures can determine which techniques is most appropriate spatial domain or frequency domain methods, Buck (1977).

1-1 Image processing in nuclear medicine:

There is significant development in medical imaging and this return to software development which in turn has provided a major impetus for new algorithms in signal and image processing, Mallat, (1999). Image processing is a set of techniques in which the data from an image are analyzed and processed using   algorithms and tools to enhance certain image information, noise removal, restoration, Feature detection, compression and image analysis give Segmentation, image registration, and also allow to The processing of an image permits the extraction of useful parameters and increases the possibility of detection of small lesions more accurately. Image processing in nuclear medicine serves three major purposes: the reconstruction of the images acquired with tomographic (SPECT) techniques,, the quality improvement of the image for viewing in terms of contrast uniformity and spatial resolution, and the preparation of the image in order to extract useful diagnostic qualitative and quantitative information medical images analysis and enhancement by image processing, Lyra (2011).

1-2 Problem of the study:

Inaccurate Performance test may lead to miss location in certain point so quality control is important to check the quality of images .medical images are often deteriorated by noise due to various interference and other factors associated with image process and data acquisition system . The nature of the

physiological system under investigation and procedures used in imaging also diminished the contrast and visibility of details. Radiation is major risk in medical imaging, the problem is caused from overdose (whatever the reason) during the diagnosis to improve image.

1-3 Objective s of the Study:

1-3-1 General Objective:

The main objective of this thesis is to enhance bone images by using image processing technique.

1-3-2 Specific Objective:

- To measure the difference signal, contrast and SNR for each images.
- To enhance bone image by using median filter and histogram equalization function.
- To compare contrast enhancement pattern in different panoramic images using such function.
- To evaluate the usage of new nonlinear approach for contrast enhancement of soft tissues.
- To calculate signal to noise ratio.

1-4 Significant of the study:

Image processing program (IDL) and its techniques' used for interactive processing of large amounts of data (including image processing),in this situation is used in order to have high accuracy in assessing bone disease , preservation of image's overall look; preservation of the diagnostic content in the image and detection of small low contrast details in diagnostic content of the image.

1-5 Overview of study:

This study was concerned with the application of image processing technique to enhance bone images , this study will fall in five chapters : chapter one deal with the introduction, it represent statement of the study problems, objectives of the study, where chapter two coati the background material of the thesis especially it discusses the use of image processing and different method use to enhance an image in nuclear medicine, chapter three describe materials and method used, where chapter four presents the results and five deal with discussion ,conclusion and recommendations.

Chapter Two

Literature Review

2-1 Nuclear medicine imaging procedures:

Nuclear medicine imaging procedures are noninvasive and, with the exception of intravenous injections, are usually painless medical tests that help physicians diagnose and evaluate medical conditions. These imaging scans use radioactive materials called radiopharmaceuticals or radiotracers. Depending on the type of nuclear medicine exam, the radiotracer is either injected into the body, swallowed or inhaled as a gas and eventually accumulates in the organ or area of the body being examined. Radioactive emissions from the radiotracer are detected by a special camera or imaging device that produces pictures and provides molecular information, Mark (2016). The new modality of nuclear medicine imaging is hybrid technique it combination of nuclear medicine images with the anatomic imaging modalities, such as CT or MRI, can enhance the clinical information from both modalities and bring on the synergetic effects by merging the information. For example, the accurate anatomic localization, correlative studies, partial volume correction, and statistical reconstruction based on the anatomic prior are possible by combination. Before the development of multimodal imaging devices, software co-registration and fusion technologies were available. However, these technologies were used for limited clinical purpose because it is time-consuming, non user friendly and unsuccessful outside brain, Dong (2012). In addition, manufacturers are now making single photon emission computed tomography/computed tomography (SPECT/CT) and positron emission tomography/computed tomography (PET/CT) units that are able to perform both imaging exams at the same time. An emerging imaging technology, but not readily available at this time is PET/MR Special camera or imaging devices used in nuclear medicine include the gamma camera and single-photon emission-computed tomography

(SPECT). The gamma camera, also called a scintillation camera, detects radioactive energy that is emitted from the patient's body and converts it into an image. The gamma camera does not emit any radiation. The gamma camera is composed of radiation detectors, called gamma camera heads, which are encased in metal and plastic and most often shaped like a box, attached to a round circular donut shaped gantry. The patient lies on the examination table which slides in between the parallel gamma camera heads which are suspended over the examination table and located beneath the examination table. Sometimes, the gamma camera heads are oriented at a 90 degree angle and placed over the patient's body. SPECT involves the rotation of the gamma camera heads around the patient's body to produce more detailed, three-dimensional images. A PET scanner is a large machine with a round, doughnut shaped hole in the middle, similar to a CT or MRI unit. Within this machine are multiple rings of detectors that record the emission of energy from the radiotracer in patient body. In some centers, the nuclear medicine scans can be superimposed, using software or hybrid cameras, on images from modalities such as CT or MRI to highlight the part of the body in which the radiopharmaceutical is concentrated. This practice is often referred to as image fusion or co-registration, for example SPECT/CT and PET/CT. The fusion imaging technique in nuclear medicine provides information about the anatomy and function, which would otherwise be unavailable or would require a more invasive procedure or surgery, Mark (2016).

2-2 Nuclear medicine image acquisition:

Image acquisition (or formation) studies the physical mechanism by which particular type of imaging device s generated image observations, and it also investigates the associated mathematical models and algorithms employed by the computers integrated into such imaging devices, Tony (2013).The gamma

emitted from patient may be acquired in various forms: static, dynamic, gated, or tomographic images.

Static images:Static image is used to collect images of different region of the body or differently angled (oblique) views of particular region of interest. For example bone scan composed of static images of 12 different regions of the body. In any cases there is very little change in the distribution of nuclide in organ of interest while the images are being required, Rachel (2006).

Dynamic images:If the distribution of nuclide in the organ is changing rapidly and it is important to record this change, multiple rapid mages of particular region of interest are acquired .this type of image acquisition is called dynamic imaging. it is used for example , to collect sequential 1-second images (called frames) of vascular flow of nuclide through the organ of interest, Rachel (2006).

Multigated acquisition (MUGA) scans:A mitigated acquisition (MUGA) scan is a nuclear medicine imaging test that checks how well the heart is pumping during rest or exercise. A Muga scan uses a radioactive material or tracer (radionuclide) that targets the heart, along with a gamma camera and a computer to create images of the blood flowing through the heart.
An MUGA scan is also called gated equilibrium radionuclide ventriculography (RVG), gated equilibrium radionuclide angiography (RNA) or cardiac blood-pool imaging. An MUGA may be done to, check how well the heart is pumping MUGA is used to evaluate the following: the size of the heart chambers, the pumping action of the lower ventricles, any abnormalities in the wall of the ventricles, MUGA is especially used with anthracyclines such as doxorubicin (Adriamycin), which can affect heart function finally the scan may be done before and periodically during chemotherapy to determine that it is safe to continue with chemotherapy, Fischbach (2009)

2-2-1 Image acquisition techniques:

The digital X and Y signals and Z signal for each event detected by the camera crystals are used by computer to generate an image.

*Matrix mode:*The most common form of image acquisition is called matrix or frame mode .this achieved by dividing the camera field of view into regular matrix of picture elements or pixels. Each pixel is assigned a unique memory location in the computer. The value stored in this location is the number of gamma- ray events which have been detected in the corresponding location on camera face. the number and hence size of the pixel is important and depend on (i)the available computer memory(ii)the total number of image to be acquired ,(iii)the number of counts contained in each image and(iv)the required temporal and spatial resolution. Large matrix size result in good resolution but require more memory or disk storage space. It is possible to reduce the total data storage requirement by recording in byte mode, provided the number of count in each pixel is low, Middleton (1989).

*List mode:*If very good temporal resolution is required, or the required temporal resolution is not known in advance (for example first pass cardiac studies) then list mode acquisition is used. In this image data is stored as a list of X and Y coordinates of each detected event (one byte for X and one byte for Y) along with regular timing data. For low count rate studies less memory will be required than for matrix mode, but in general more memory required. However, some additional software and extra processing time is required to format such data into suitable matrix mode image for display. It had advantage several matrix mode studies with different frame times can be produced from original data, Middleton (1989).

2-3 Bone Scintigraphy:

A bone Scintigraphy (bone scan) is a diagnostic study used to evaluate the distribution of active bone formation in the body, Bone Scintigraphy is one of the most frequently performed of all radionuclide procedures. Radionuclide bone imaging is quick, relatively inexpensive, widely available, and exquisitely sensitive and is invaluable in the diagnostic evaluation of numerous pathologic conditions. The procedure is performed with technetium-99m–labeled diphosphonate. These compounds accumulate rapidly in bone, and by 2–6 hours after injection, about 50% of the injected dose is in the skeletal system. The uptake mechanisms of diphosphonate have not been completely elucidated. Presumably they are adsorbed to the mineral phase of bone, with relatively little binding to the organic phase. The degree of radiotracer uptake depends primarily on two factors: blood flow and, perhaps more importantly, Tomas (2003) a nuclear scanning tests to find certain abnormalities in bone. It was primarily used to help diagnose a number of conditions relating to bones, including: cancer of the bone or cancers that have spread (metastasized) to the bone, locating some sources of bone inflammation (e.g. bone pain such as lower back pain due to a fracture), the diagnosis of fractures that may not be visible in traditional X-ray images, and the detection of damage to bones due to certain infections and other problems. it is one of a number of methods of bone imaging Such imaging studies include magnetic resonance imaging (MRI) X-ray computed tomography (CT), a nuclear bone scan is a functional test: it measures an aspect of bone metabolism or bone remodeling, which most other imaging techniques cannot. The nuclear bone scan competes with the FDG-PET scan in seeing abnormal metabolism in bones, but it is considerably less expensive. Nuclear bone scans are not to be confused with the completely different test

often termed a (bone density scan) DEXA or DXA, which is a low-exposure X-ray test measuring bone density to look for osteoporosis and other diseases where bones lose mass, without any bone rebuilding activity. In the nuclear medicine technique, the patient is injected (usually into a vein in the arm or hand, occasionally the foot) with a small amount of radioactive material such as 740 MBq of technetium-99m-MDP and then scanned with a gamma camera, a device sensitive to the radiation emitted by the injected material. Two-dimensional projections of Scintigraphy may be enough, but in order to view small lesions (less than 1cm), single photon emission computed tomography (SPECT) or positron emission tomography (PET). Half of the radioactive material leaves the body through the kidneys and bladder in urine. Anyone having a study should empty their bladder immediately before images are taken. In evaluating for tumors, the patient is injected with the radioisotope and returns in 2–3 hours for imaging. Image acquisition takes from 30 to 70 minutes; the three phase bone scan detects different types of pathology in the bone the first phase is also known as the nuclear angiogram or the flow phase. During this phase, serial scans are taken during the first 2 to 5 seconds after injection of the Technetium-99m-MDP. This phase typically shows perfusion to a lesion. Cellulites' shows up more in phase 1 and phase 2 scan, but not in phase 3. Pathology that is more moderate to severe will show more in the first two phases. Pathology that is chronic or partially treated will be more pronounced in the third phase of a triphasic scan. The second phase image, also known as the blood pool image is obtained five minutes after injection. This shows the relative vascularity to the area. Areas with moderate to severe inflammation have dilated capillaries, which is where the blood flow is stagnant and the radioisotope can "pool". This phase shows areas of intense or acute inflammation more definitively compared with the third phase. The third phase, delayed phase, is obtained 3 hours after the injection, when the majority of the radioisotope has been

metabolized. This phase best shows the amount of bone turnover associated with a lesion. A typical radiation dosage obtained during a bone scan is 6.3 mSv Khalil, (2011).

2-4 Image quality in nuclear medicine:

There is no objective definition of image quality; it is more a matter of the observer's subjective judgment. In nuclear medicine, the basis of image quality is the ability of the imaging device to detect differences in the uptake of a radiopharmaceutical in a lesion and its surroundings. Hence, an image of high quality is one that can reproduce this contrast in order to secure a correct diagnosis. However, several factors will degrade the image quality, some of which are due to inherent properties of the imaging device such as spatial resolution, energy resolution, non-uniformity, or distortions. Other degrading factors are dependent on the patient and organ localization. A large patient will increase the influence of scattered photons. An organ deep in the body will be overlapped by other tissues, which will increase the background registrations. Patient and organ movements will also degrade the image quality. Finally, some important factors are due to the operation of the imaging device and can be optimized by the user. These include spatial resolution by keeping the distance between the detector and the patient as short as possible and noise reduction by selecting an optimum examination time and matrix size. Scattered radiation can be reduced by a proper setting of the pulse height analyzer.

Object contrast: The main purpose of any device is to record the details of an object faithfully in its image. in nuclear medicine , the object contrast is created in organ of interest by the use of a radio -pharmaceutical that either selectively localized I the abnormal tissue as compared with the normal tissue, or vice versa. In either case, the easier is to detect an abnormality. There for, radiopharmaceutical that produce greater contrast in the lesion

have better detect ability than those produce small contrast Chandra et al (2004). Contrast of an image is relative variation in count densities between adjacent areas in the image of an object; it gives the measure of delectability of an abnormality relative to normal Saha (1993). For quantitative purpose we may defined the object contrast Co as follow: Co= (concentration in abnormal tissue -concentration in normal tissue)\concentration in normal tissue Chandra et al (2004).

Spatial resolution: Is defined as ability of imaging modality to reproduce the details of non uniform radioactive distribution. The spatial resolution is separated into intrinsic resolution (scintillator, photomultiplier tubes and electronic circuit) and system resolution (collimator, scintillator, photomultiplier tubes and electronic circuit). The intrinsic resolution depends on the thickness of the scintillation crystal while the system resolution depends mainly on the distance from the emitting source to collimator. The resolution of gamma camera limited by several factor some of these are patient motion, the statistical fluctuation in the distribution of visible photons detected and the collimator geometry Wemick et al (2004).

*Statistical (Quantum) Noise:*for reproducing of an object, even with high contrast, a good image device with good resolution is not itself, enough. The human eye is cap pale of seeing minute details of a well –lit object but fails to perceive even large object in dark room. Hence, the mount of available light (number of photon) is another important parameter affecting the visualization of the detail of an object. In nuclear medicine, the statistical noise of an image related to information density, which is defined as the number of gamma rays detected per cm2 of an object. If we multiplied the information density by the area of the object we obtain the average number of photon in image. The statistical noise or error of N counts in an image equals, Chandra et al (2004).

*Energy resolution:*even through gamma rays of the same energy are absorbed in the detector, pulse of different amplitude are produced because of the

statistical variation in the production of light photo in the detector. This result in broaden of photo peak. The width of photo peak or sharpness of the peak (I.e., the energy resolution of the detector) predicts the ability of the crystal to discriminate between the gamma ray photons of dissimilar energies. The energy resolution of a system is given by the full width at half maximum (FWHM) amplitude of the photo peak and is expressed as percentage of the photon energy. The energy resolution depends on the photon energy. The higher the photon energy, the better the energy resolution (i.e., smaller FWHM), pulse production, Saha (1993).

*Non- uniformity:*the Non- uniformity is the measure of the slightly different response of different areas of the detector to irradiation by a uniform source. This may be measured with or without collimator. Although an image obtained on photographic film is adequate for daily assessment, quantitative data from digital (computer) image are necessary for comparison purpose. In latter case, it is the variation in pixel count value which is analyzed.It is usual to carry out for both the geometrical field of view (GFOW) – The whole usable field of view – and the central field of view .for both the mean and stander deviations (SD) of pixel count are calculated, Elliott (1989)

2-5 Image Processing:

Image processing is a method to convert an image into digital form and perform some operations on it, in order to get an enhanced image or to extract some useful information from it. It is a type of signal dispensation in which input is image, like video frame or photograph and output may be image or characteristics associated with that image. Usually Image Processing system includes treating images as two dimensional signals while applying already set signal processing methods to them. It is among rapidly growing technologies today, with its applications in various aspects of a business. Image Processing forms core research area within engineering and computer

science disciplines too. Image processing basically includes the following three steps:

Importing the image with optical scanner or by digital photography, Analyzing and manipulating the image which includes data compression and image enhancement and spotting patterns that are not to human eyes like satellite photographs, and Output is the last stage in which result can be altered image or report that is based on image analysis, Tinku (2005).

2-5-1 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, and image Recognition – Distinguish the objects in an image.

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, Tinku (2005).

2.6 Image analysis and processing in nuclear medicine:

In the last several decades, medical imaging systems have advanced in a dynamic progress. There have been substantial improvements in characteristics such as sensitivity, resolution, and acquisition speed. New techniques have been introduced and, more specifically, analogue images have been substituted by digital ones. As a result, issues related to the digital images' quality have emerged, Nailon (2010).

*Digital images:*The digitization of images generally consists of two concurrent processes Image Sampling: This process is used to digitize the spatial information in an image. It is typically achieved by dividing an image into a square or rectangular array of sampling points. Each of the sampling points is referred to as a picture element - or pixel to use computer jargon**.** Naturally, the larger the number of pixels, the closer the spatial resolution of the digitized image approximates that of the original analogue image. Image Quantization: This process refers to the digitization of the brightness information in an image. It is typically achieved by representing the brightness of a pixel by an integer whose value is proportional to the brightness. This integer is referred to as a 'pixel value' and the range of possible pixel values which a system can handle is referred to as the gray scale. Naturally, the greater the gray scale, the closer the brightness information in the digitized image approximates that of the original, analogue image , Gonzalez et al (2009).
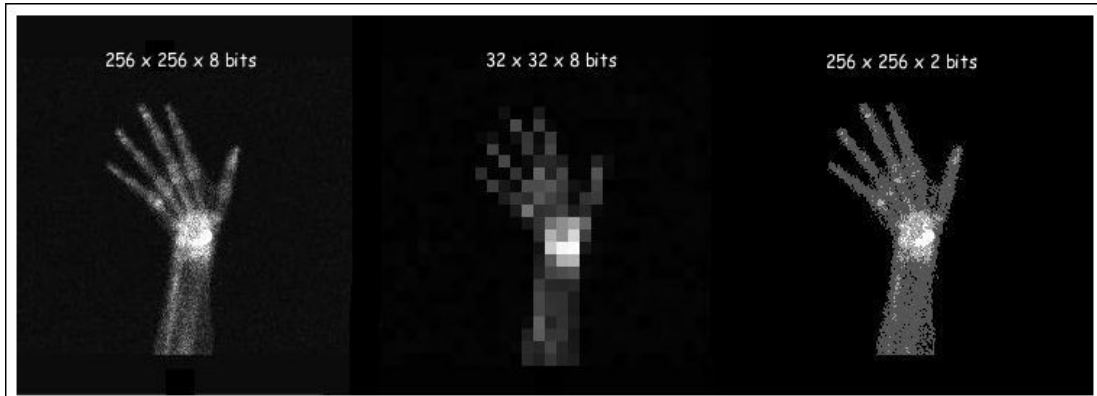
Figure (2.1) a bone scan of a patient's hand displayed with digital image resolutions of 256x256x8 bits, 32x32x8 bits and 256x256x2 bits, Maher et al (2006).

In all modern nuclear medicine imaging systems, the images are displayed as an array of discrete picture elements (pixels) in two dimensions (2D) and are referred as digital images. Each pixel in a digital image has an intensity value and a location address, In a nuclear medicine image the pixel value shows the number of counts recorded in it. The benefit of a digital image compared to the analogue one is that data from a digital image are available for further computer processing, Lyra et al (2011).
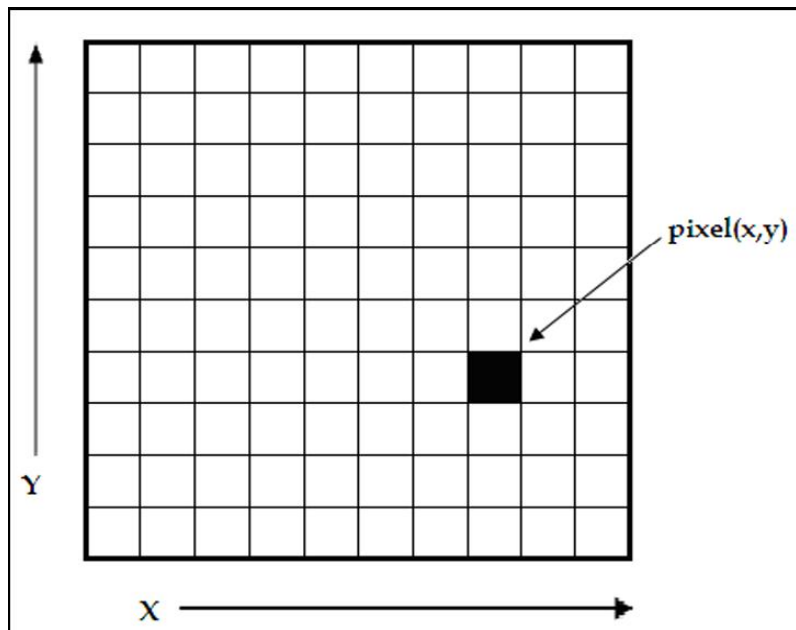
Figure (2.2) a digital image is a 2D array of pixels each pixel is characterized by its (x, y) coordinates and its value, Lyra, et al (2011).

Digital images are characterized 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 of Nuclear medicine images matrices are nowadays, ranged from 64×64 to 1024×1024 pixels ,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). Nuclear medicine images are frequently represented as 8- or 16- bit images.

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 are improved, Lyra, et al, (2011).

*Image filtering:*The factors that degrade the quality of nuclear medicine images result in blurred and noisy images with poor resolution. One of the most important factors that greatly affect the quality of clinical nuclear medicine images is image filtering. Image filtering is a mathematical processing for noise removal and resolution recovery. The goal of the filtering is to compensate for loss of detail in an image while reducing noise. Filters suppressed noise as well as deblurred and sharpened the image. In this way, filters can greatly improve the image resolution and limit the degradation of the image. An image can be filtered either in the frequency or in the spatial domain. In the first case the initial data is Fourier transformed,

multiplied with the appropriate filter and then taking the inverse Fourier transform, re-transformed into the spatial domain.

The filtering in the spatial domain demands a filter mask (it is also referred as kernel or convolution filter). The filter mask is a matrix of odd usually size which is applied directly on the original data of the image. The mask is centered on each pixel of the initial image. For each position of the mask the pixel values of the image is multiplied by the corresponding values of the mask. The products of these multiplications are then added and the value of the central pixel of the original image is replaced by the sum. This must be repeated for every pixel in the image.

If the filter, by which the new pixel value was calculated, is a linear function of the entire pixel values in the filter mask (e.g. the sum of products), then the filter is called linear. If the output pixel is not a linear weighted combination of the input pixel of the image then the filtered is called non-linear. According to the range of frequencies they allow to pass through filters can be classified as low pass or high pass. Low pass filters allow the low frequencies to be retained unaltered and block the high frequencies. Low pass filtering removes noise and smooth the image but at the same time blur the image as it does not preserve the edges. High pass filters sharpness the edges of the image (areas in an image where the signal changes rapidly) and enhance object edge information. A severe disadvantage of high pass filtering is the amplification of statistical noise present in the measured counts.
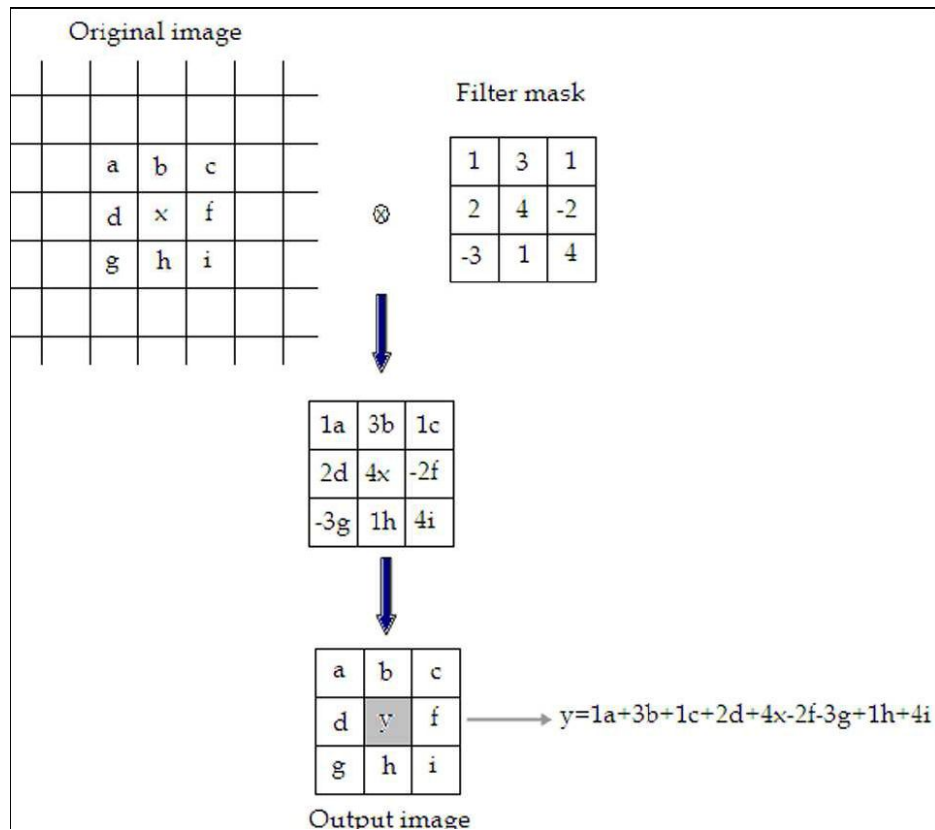
Figure 2.3 Filtering process in spatial domain, Lyra et al (2011)

The most common filters used: the mean, median and Gaussian filter.

Mean filter: is the simplest low pass linear filter. It is implemented by replacing each pixel value with the average value of its neigh bourhood. Mean filter can be considered as a convolution filter. The smoothing effect depends on the kernel size. As the kernel size increases, the smoothing effect increases too, Lyra et al (2011).

Median filter: is a non linear filter. Median filtering is done by replacing the central pixel with the median of all the pixels value in the current neighborhood. A median filter is a useful tool for impulse noise reduction the impulse noise (it is also known as salt and paper noise) appears as black or (/and) white pixels randomly distributed all over the image, Toprak and Guler (2006)

Gaussian filter: is a linear low pass filter. A Gaussian filter mask has the form of a bell shaped curve with a high point in the centre and symmetrically tapering sections to either side. Application of the Gaussian filter produces, for each pixel in the image, a weighted average such that central pixel contributes more significantly to the result than pixels at the mask edge (Lyra, et al, 2011). The degree of smoothing depends on the standard deviation. The larger the standard deviation, the smoother the image is depicted. The Gaussian filter is very effective in the reduction of impulse and Gaussian noise. Gaussian noise is caused by random variations in the intensity and has a distribution that follows the Gaussian curve, Lyra (2011).

The Fourier transform (ft) in image processing:

In an attempt to convey more effectively the concept on which the transform is based; it does in no way substitute for a rigorous mathematical treatment, and is solely aimed at supporting your understanding of image filtering. This presentation will demonstrate that images can be thought about from both spatial and spatial frequency perspectives. The spatial perspective is the conventional way of presenting image data and relates to real world parameters such as distance and time. An image may also be considered as consisting of a large number of spatial frequencies interacting with each other. This aspect will be examined using a chest radiograph, an example of medical image which consists of a very broad range of spatial frequencies. The Fourier transforms (ft) the image data from the spatial representation to the spatial frequencyrepresentation and the inverse **FT** performs the reverse operation, Gorman et al (2008).
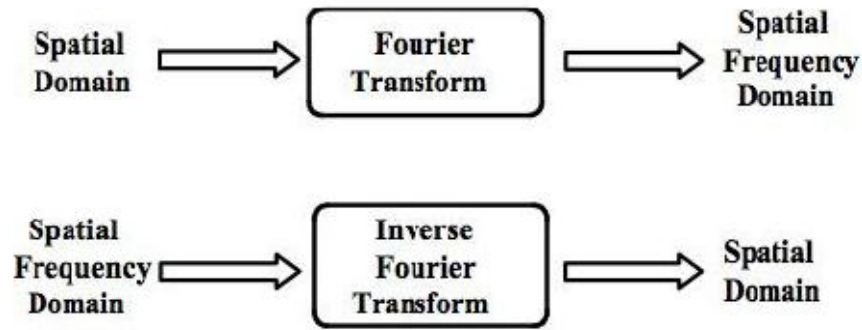
Figure (2.4) Fourier transform convert image data, Maheret al (2006)

Illustration of the use of the Fourier Transform; The FT and its inverse allow us to convert image data from the spatial to spatial frequency domains and vice versa, respectively. A more complicated 2-D Fourier spectrum is obtained when a chest radiograph is transformed to the spatial frequency domain as illustrated in the next figure. The transformed data show a broad range of spatial frequencies, with significant vertical and horizontal features, as might be expected from the horizontal ribs and vertical vertebral column displayed in the radiograph, Gorman et al (2008).

2.7 Image processing techniques with IDL:

*Contrast enhancement:*One of the very first image processing issues is the contrast enhancement. The acquired image does not usually present the desired object contrast. The improvement of contrast is absolutely needed as the organ shape, boundaries and internal functionality can be better depicted. In addition, organ delineation can be achieved in many cases without removing the background activity.

Byte-Scaling: The scaling process is linear with the minimum data value scaled to 0 and the maximum data value scaled to 255. The BYTSCL function can be used to perform this scaling process. If the range of the pixel values within an image is less than 0 to 255, the BYTSCL can use function to

increase the range from 0 to 255. This change will increase the contrast within the image by increasing the brightness of darker regions. Keywords to the BYTSCL function also allow decreasing contrast by setting the highest value of the image to less than 255.

HIST_EQUAL: used 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.

Adaptive histogram equalization involves applying equalization based on the local region surrounding each pixel. Each pixel is mapped to intensity proportional to its rank within the surrounding neighborhood. This type of equalization also tends to reduce the disparity between peaks and valleys within the image's histogram. ADAPT_HIST_EQUAL function used to perform the adaptive histogram equalization process within IDL. Like the HIST_EQUAL function, the ADAPT_HIST_EQUAL function results in a modified image, which has a different histogram than the original image.

*Smoothing an Image:*Smoothing is often used to reduce noise within an image or to produce a lesspixilated image. Most smoothing methods are based on low pass filters. Smoothing is also usually based on a single value representing the image, such as theaverage value of the image or the middle (median) value.

Sharpening an Image: Sharpening an image increases the contrast between bright and dark regions to bring out features.The sharpening process is basically the application of a high pass filter to an image. The following array is a kernel for a common high pass filter used to sharpen an image; filters can be applied to images in IDL with the CONVOL function.

Image interpolation: Interpolation is a topic that has been widely used in image processing. It constitutes of the most common procedure in order to resample an image, to generate a new image based on the pattern of an existing one. Moreover, re-sampling is usually required in medical image processing in order to enhance the image quality or to retrieve lost information after compression of an image, Lehmann et al (1999). The interpolation process, these options include the resizing of an image according to a defined scaling factor, the choice of the interpolation type and the choice of low pass filter. The general command that performs image resizing is imresize. However, the way that the whole function has to be written depends heavily on the characteristics of the new image. The size of the image can be defined as a scaling factor of the existing image or by exact number of pixels in rows and columns. Spatial interpolation techniques here the pixel values of unknown pixels are estimated using the pixel values of known neigh bouring pixels. Suppose the image above is zoomed again and suppose that this time the known pixels are distributed to the corners of the zoomed image, Lyra et al (2011).
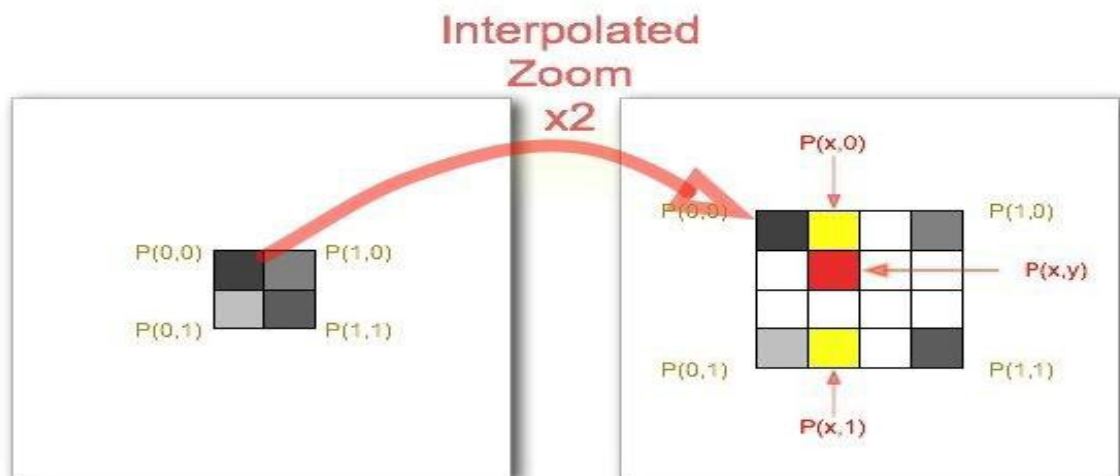

Figure 2.5 Interpolation applied to zooming an image by a factor of two,
Maher et al (2006).

Image segmentation: The image segmentation describes the process through which an image is divided into constituent parts, regions or objects in order to isolate and study separately areas of special interest. This process assists in detecting critical parts of a nuclear medicine image that are not easily displayed in the original image. The process of segmentation has been developed based on lots of intentions such as delineating an object in a gradient image, defining the region of interest or separating convex components in distance-transformed images. Attention should be spent in order to avoid 'over segmentation' or 'under-segmentation'. In nuclear medicine, segmentation techniques are used to detect the extent of a tissue, an organ, a tumor inside an image, the boundaries of structures in cases that these are ambiguous and the areas that radiopharmaceutical concentrate in a greater extent. Thus, the segmentation process serves in assisting the implementation of other procedures; in other words, it constitutes the fundamental step of some basic medical image processing, Gopal and Saha (2006).

There are two ways of image segmentation: based on the discontinuities and based on the similarities of structures inside an image. In nuclear medicine images, the discontinuity segmentation type finds more applications. This type depends on the detection of discontinuities or else, edges, inside the image using a threshold. The implementation of threshold helps in two main issues: the removal of unnecessary information from the image (background activity),the appearance of details not easily detected. The edge detection uses the command edge. In addition, a threshold is applied in order to detect edges above defined grey-scale intensity. Also, different methods of edge detection can be applied according to the filter each of them utilizes. The most useful methods in nuclear medicine are the 'Sobel', 'Prewitt', 'Roberts', 'Canny' as well as 'Laplacian of Gaussian'. It is noted that the image is immediately transformed into a binary image and edges are detected. In nuclear medicine,

the methods that find wide application are the sorbel, prewitt and canny another application of segmentation in nuclear medicine is the use of gradient magnitude. The original image is loaded then the edge detection method of sobel is applied in accordance with a gradient magnitude which gives higher regions with higher grey-scale intensity, Gopal and Saha (2006).

*Image registration:*Is used for aligning two images of the same object into a common coordinate system presenting the fused image, The images can be acquired from different angles, at different times, by different or same modalities. A typical example is the combination of SPECT and CT images or PET and CT, Image registration is used mainly for two reasons: i) to obtain enhanced information and details from the image for more accurate diagnosis or therapy (Li & Miller, 2010) and, ii) to compare patient's data (Zitova & Flusser, 2003). IDL can be used in order to perform such a process. The whole procedure shall follow a specific order. The first step of the procedure includes the image acquisition and enhancements in brightness and contrast. The next step includes the foundation of a spatial transformation between the two images. The final step in image registration is the overlapping of the two images allowing a suitable level of transparency. A new image is created containing information from both pictures from which, the first has been produced, Delbeke et al (2009).

*Signal-to-Noise Ratio:*In order to visualize an object in a specific image, the object must have different brightness that its surroundings. Thus, the contrast of the object (signal) must overcome the image noise. The signal-to-noise ratio (SNR) is an expression used to describe the power ratio between the signal (significant information) and the background noise. In one imaging application view, these quantities would be a fixed known activity concentration and the standard deviation of its inherently fluctuating measured values attributable to the imaging protocol, Smith (1997)

.Considering that the mean describes what is being measured (x) and the standard deviation represents the amount of noise and other interferences, $\sigma(N)$ one can define the SNR as demonstrated on ***Equation 1*** ,Budes et al (2005)

$$SNR = x \backslash (N)$$

2-8 previous study:

Hamid.et al., (2015) mentioned that Medical imaging plays an important role in monitoring the patient's health condition and providing an effective treatment. . However, the existence of several objects overlapping in an image and the close proximity of adjacent pixels values in medical images make the diagnostic process a difficult task, a test method based on morphological transforms to enhance the quality of various medical images. In this method, a disk-shaped mask whose size fits that of the original input image is chosen for morphological operations. Afterward, the proposed filter from the Top-Hat transforms is applied to the image, using the chosen mask in a multi-step process. At each step, the size of the mask is increased. Consequently, an enhanced image is provided for each mask size. The number of required steps and the final enhanced image are determined based on the Contrast Improvement Ratio (CIR) measure. Indeed, this approach applies an exfoliation process on the images, in which one or several objects in the image are prominently manifested using morphological filter, hence provide an appropriate image for analysis. The results in this research indicate that the proposed approach makes a better contrast and works much better than the other existing methods in improving the quality of medical images.

Yanch, et al. (2014) also improving the quality of images in single photon emission computed tomography (SPECT) using transaxial images of the liver and brain. Material and method Deconvolution of the nuclear medicine data by a point source response function (PSRF) acquired previously in a scattering medium attempts to compensate for scattered radiation within the patient. The average geometric response of the collimator of the gamma camera is also compensated for with this technique. Three patients with known metastatic lesions in the liver and three with primary lesions in the brain were imaged. Clinical assessment of reconstructed slices both before

and after Deconvolution demonstrates that compensating for the effects of scatter and of collimator blurring leads to enhanced detail of pathological lesions. In all cases, cold lesions seen prior to Deconvolution were enhanced in detail and, in addition, new lesions were seen with this technique.

Miller et al (1995) *aims to* introduce a method using an image sequence processing algorithm, called the simultaneous diagonalization (SD) filter, to form one new image in which a desired feature is enhanced and one or more undesired features (and noise) are suppressed in the filtered image. This filtering technique, applied to a long noisy image sequence, can be used to achieve significant data compression for image storage and provide surprisingly good enhanced image reconstructions Material and method: SD filtering is applied to a temporal image sequence, a renogram, with compression of a very noisy 180-image sequence to a 4-image set. The renogram, a nuclear medicine technique, was chosen due to its low signal-to-noise ratio over a long image sequence. Before the application of the SD filter, classical image processing techniques, median and averaging filtering, are used as a preliminary method to reduce the image sequence noise content. The result was compared to any of the images in the original image sequence; the reconstructed images are remarkably good. The SD filter with prefiltering, thus, can collect information distributed over a 180-image temporal sequence with low signal-to-noise ratio.

Nuclear medicine (NM) images inherently suffer from large amounts of noise and blur. Since the purpose of the present work was to reduce the noise and blur while maintaining image integrity for improved diagnosis. The proposed solution is to increase image quality after the standard pre- and post-processing undertaken by a gamma camera system. Are carried out using Mean Field Annealing (MFA) is the image processing technique used in this research. It is a computational iterative technique that makes use of the Point

Spread Function (PSF) and the noise associated with the NM image. MFA is applied to NM images with the objective of reducing noise while not compromising edge integrity. Using a sharpening filter as a post-processing technique (after MFA) yields image enhancement of planar NM images ,Marwal et al (2007).

Yousif, (2014) aimed to present an appropriate approach for the robust estimation of noise statistic in cardiac scintigraphy images, To achieve maximum image quality after denoising, material and method a new, low order, local adaptive Gaussian Scale Mixture model is presented, which accomplishes nonlinearities from scattering. State of art methods use multi scale filtering of images to reduce the irrelevant part of information, based on generic estimation of noise. The analysis approach is tested on 50 samples from a database of 50 cardiac images and the results are cross validated by medical experts. In this study, prominent constraints are firstly preservation of image's overall look; secondly preservation of the diagnostic content in the image and thirdly detection of small low contrast details in diagnostic content of the image. As shown in previously, state of the art methods provide non-convincing results. The new approach is funded on an attempt to interpret the problem from the view of blind source separation (BSS), thus to see the cardiac image as a simple mixture of (unwanted) background information, diagnostic information and noise.

In addition stated that to enhance the nuclear medicine images by using Filtering Technique in order to evaluate contrast enhancement pattern in different nuclear medicine images such as grey color and to evaluate the usage of new nonlinear approach for contrast enhancement of soft tissues in Nuclear Medicine images. The data analyzed by using Mat Lab program, the main techniques of enhancement used in this study were Top-hat filtering and Deblurring Images Using the Blind Deconvolution Algorithm. In this thesis,

prominent constraints are firstly preservation of image's overall look; secondly preservation of the diagnostic content in the image and thirdly detection of small low contrast details in diagnostic content of the image. As shown in previously, state of the art methods provide non-convincing results. The new approach is funded on an attempt to interpret the problem from the view of blind source separation (BSS), thus to see the panoramic image as a simple mixture of (unwanted) background information, diagnostic information and noise ,Yousif et al (2014).

Augustine, et al., *aim to*determine theoretical activities in kidney and bladder, which were compared with the experimental data, Radionuclide activities in the kidney and bladder, have been estimated experimentally from practical data 3 h after injection of Tc-99m MDP, using conjugate view methodology. The study involved sixty-five patient images from the database of a nuclear medicine department in Ghana. Time–activity curve was stimulated with Mat Lab computer program using biokinetic model published in MIRD Report 13. The model was used to determine theoretical activities in kidney and bladder, which were compared with the experimental data. The result was estimated radionuclide activities for the kidney and bladder were both minimal in the experimental case comparative to the theoretical. The fraction of injected activity in kidney and bladder were less than 1% of injected activity, and hence kidney and bladder could be seen to receive very low doses during bone scans.

Image segmentation plays a crucial role in many medical-imaging applications, by automating or facilitating the delineation of anatomical structures and other regions of interest. We present a critical appraisal of the current status of semi automated and automated methods for the segmentation of anatomical medical images. Terminology and important issues in image segmentation are first presented. Current segmentation approaches are then

reviewed with an emphasis on the advantages and disadvantages of these methods for medical imaging applications. We conclude with a discussion on the future of image segmentation methods in biomedical research, Dung et al (2000).

David et al (1992) stated in same context wide variety of image segmentation techniques have been proposed for the measurement of organ or lesion volumes in SPECT images. Evaluation of the relative performance of the various methods is difficult due to wide variations in system response characteristics, size, shape, and contrast of the imaged objects, and image acquisition and processing techniques. Selected image segmentation methods for volume quantization in SPECT were applied to a set of simulated SPECT images containing objects ranging in volume from 1.8 to 113.1 cc. The specific segmentation methods included: (1) operator drawn regions of interest, (2) count-based methods, (3) three levels of fixed thresholds, (4) an adaptive threshold (GLH method), (5) a two-dimensional (2-D) edge detection method, and (6) a three-dimensional (3-D) edge detection method. The result was In general, the 3-D edge detection method required minimal operator intervention while providing the most accurate and consistent estimates of object volume across changes in object contrast and size.

Krom et al (2013) stated that reducing radiation dose and scanning time of diagnostic test is often desirable .one method uses image enhancement software such as Pixon which process the lower- count scans and aim to produce high –quality images. However, it is essential that diagnostic accuracy is not compromised. Material and method we compared the level of agreement between clinical using stander scans , with half- count and Pixon enhanced half –count .bone scan from 150 patients referred to diagnose metastatic disease were degraded by process of Poisson-preserving binomial resembling to generate equivalent half-count scans and then processed by

Pixon soft ware to recreate the original high quality scans. The study yield, in randomized, blinded manner for metastatic disease (yes\no) and assigned a confidence level to this diagnosis. level of agreement between clinicians were calculated for the full- count ,half count ,and Pixon enhanced half count and between scanning method for each clinician .agreement between clinician for stander full-count scans was92%(+_4%,k=0,80),compared with92%(+_4%,k=0,79) for half –count and 87%(+_2%,k=0,88) for Pixon –processed half-count scans. The Pixon enhancement step improved neither objective diagnostic agreement nor clinical confidence.

Maria et al (2011) stated that the quality of (SPECT) images is graded by several factors such as noise because of the limited number of count, attenuation, or scatter of photons. The aim of this work is to describe the most widely used filters in SPECT application and how these affect the image quality. The choice of the filter type, the cut-off frequency and the order is major problem in clinical routine. As resulting from the overview, no filter is perfect, and the selection of the proper filters, most of the times, is done empirically. The standardization of image- processing results may limit the filter type for each SPECT examination to certain few filters and some of their parameters , also reducing image processing time ,as the filters and their parameters must be standardized before being put to clinical use.

Falk et al (2006) described that Nuclear medicine images inherently suffer from large amounts of noise and blur. the purpose of this study is to reduce the noise and blur while maintaining image integrity for improved diagnosis the proposed solution is to increase image quality after the stander pre- and post processing undertaken by gamma camera . Mean field annealing (MFA) is the image processing technique used in this research. It is computational iterative technique that makes the use of the point spread function and noise associated with the NM image MFA is applied to NM image with objective to

reducing the noise while not comprised edge integrity .using sharpening filtering as post processing technique (MFA) yields image enhancement of planar NM images and Krom et al, 2008 comment similarly.

Maryoud et al (2015) mentioned that advanced technologies in image processing and analysis are used extensively in nuclear medicine, working to improve nuclear medicine images, image data are used to gather details from location of the diseases or physiological processes. This study aims to enhancement of bone scintigraphy Image by using image processing technique and have been using MATLAB program is used to enhance the quality of the images, The random sampling consists of 10 patients who underwent bone scintigraphy scan,the study was conducted and taking information from Niles Center for Nuclear Medicine, data were collected in the period between July 2014 to January 2015. MATLAB program techniques such as Contrast-limited adaptive histogram equalization (CLAHE), histogram equalization, Adjust image intensity values or color map, 2-D median filtering and contrast stretch image, are used on this study to analyzed and Enhanced data (bone scan images). The result was a significant difference between the original image and the image that processed using MATLAB techniques, in terms of contrast especially in homogeneous areas and had been avoided the amplifying of any noise that might be present in the image by (CLAHE), extracting of the foreground from the background by using histogram as guide for threshold value and enhance the contrast of images (bone scan) by using histogram code and Contrast stretch image ,the Adjust image code used to enhance the images by increasing of contrast, the reduce of the "salt and pepper" noise by using 2-D median filtering; median filter was more effective than convolution when the goal is simultaneously reduce noise and preserve edges.

Ardenfors et al (2015) provide anew matter of reducing scan-time while maintaining sufficient image quality is a common issue in nuclear medicine diagnostics. *The aim* of the present study was to evaluate if a commercially available noise-reducing Pixon-algorithm applied on whole body bone scintigraphy acquired with half the standard scan-time could provide the same clinical information as full scan-time non-processed images. Twenty patients were administered with 500 MBq (99m) Tc-diphosphonate and scanned on a Siemens Symbia T16 system. Each patient was first imaged using a standard clinical protocol and subsequently imaged using a protocol with half the standard scan-time. Half-time images were processed using a commercially available software package, Enhanced Planar Processing, from Siemens. All images were anonym zed and visually evaluated with regard to clinically relevant lesion delectability by three experienced nuclear medicine physicians. The result of this evaluation was grouped into four BMI intervals to investigate the performance of the algorithm with regard to different patient size. Also, a comparison study was performed where the physicians compared the standard image and the processed half-time image corresponding to the same patient with regard to lesion detect ability, image noise, and artifacts. The results showed that 93 % of the processed half-time images and 98 % of the standard images were rated as sufficient or good with regard to lesion detect ability. The processed half-time images were predominately considered sufficient (65 %), whereas the majority of the standard images were graded as good (83 %). The performance of the algorithm was unaffected by patient size as the average grading of all half-time processed images was constant independent of patient BMI. The comparison study showed that the standard images were rated superior with regard to lesion detects ability, image noise, and artifacts, in 32, 65, and 23 % of the evaluations, respectively.

Chapter Three

Materials and Methods

3-1 Material:

- Personal Computer (PC)
- IDL program version.
- Gamma camera **SPECTMULTICAM 1000/MULTICAM 2000**medical imaging systems model MED Nuclear- Medizintechnnik company with dual head and camera large field of view and collimator low energy general purpose.
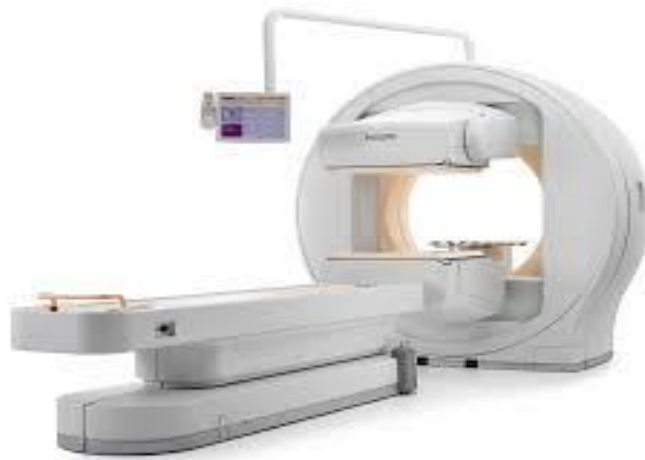

Figure (3-1) dual head gamma camera machine

3-2 methods

3-2 -1 Method of data collection:

Technique: The patient under examination must perform bone scan for many indication that may come through infection, metabolic disease, tumor (most

commonly metastasis) and metabolic bone disease .before scan ,the patient asking if he\ her underwent nuclear medicine image or diagnostic image with contrast media for another reason , if not the patient injected with 15 mci of Tc^{99m} MDP , the patient is advanced to maintain good hydration with oral fluid and to empty their bladder regularly to reduce unnecessary dose to pelvic organ. Two or four hours after injection whole body imaging take place using dual- head gamma camera, acquiring anterior and posterior view simultaneously, with patient in anatomical position.

3-2-2 Study Design:

A prospective, analytical case control study used to enhance the bone images in NM studies

3-2-3 Area of the Study:

This study conducted at Fedail hospitals, nuclear medicine department

3-2-4 Study Sample:

The study sample was consisted of 30 bone images for patient with different pathological diagnosis.

3-2-5 Duration of the study:

This study conducted in period from December 2016untill February 2017.

3-2-6 Population of the Study:

The population of this study was data set (static bone Images), with patient of different clinical diagnosis. The study include both gender with their age ranged from 18 years to 83years old.

3-2-6-1 Inclusion Criteria:

All patients withstatic bone Scintigraphy, whatever his \her diagnosis.

3-2-6-2 Exclusion Criteria:

All patients with dynamic bone Scintigraphy, SPECT bone Scintigraphy and patient underwent a surgical procedure.

3-2-7 Method of data analysis and presentation:

After that bone images were stored in computer disk were viewed by the Radiant, Ant DICOM viewer in computer to selected the images that suit the criteria of research population then uploaded into the computer based software Interactive Data Language (IDL) where the DICOM image format to suit IDL platform in order to preserve the quality of the image. Then the image were read by IDL, the user clicks on areas represents the background, weight area, black area ; in these areas a window 3×3, pixel were generated and count feature for the classes center were generated. These count features includes signal, noise, SNR and contrast factor using median filter and then histogram equalization. The algorithm scans the whole image using a window; 3×3 pixels and computes the above mentioned count features and Then the window interlaced one pixel and the same processes started over again until the entire image were enhanced for the two different image regions and then the feature was extracted. After all images were enhanced the data concerning the image count of bone (signal, noise, SNR and contrast factor) before and after enhancement entered into SPSS with its classes stepwise; to select the most discriminate features that can be used in the enhancement in bone images and then to discriminate between the different values in these images for two selected (white and black) classes.

3-2-4 Data collection variables:

All bone images selected from NM department for those having normal bone studies was selected to be enhanced and to select the proper method of enhancement using both histogram equalization and median filter in which the Signal, SNR and contrast for black and white area pre and post-enhancement.

3-2- 5 Ethical approvals:

- There was official written permission to Fedail hospital to take the data.
- No patient data will be disclosed also the data was kept in personal computer with personal password.

Chapter four

The Result
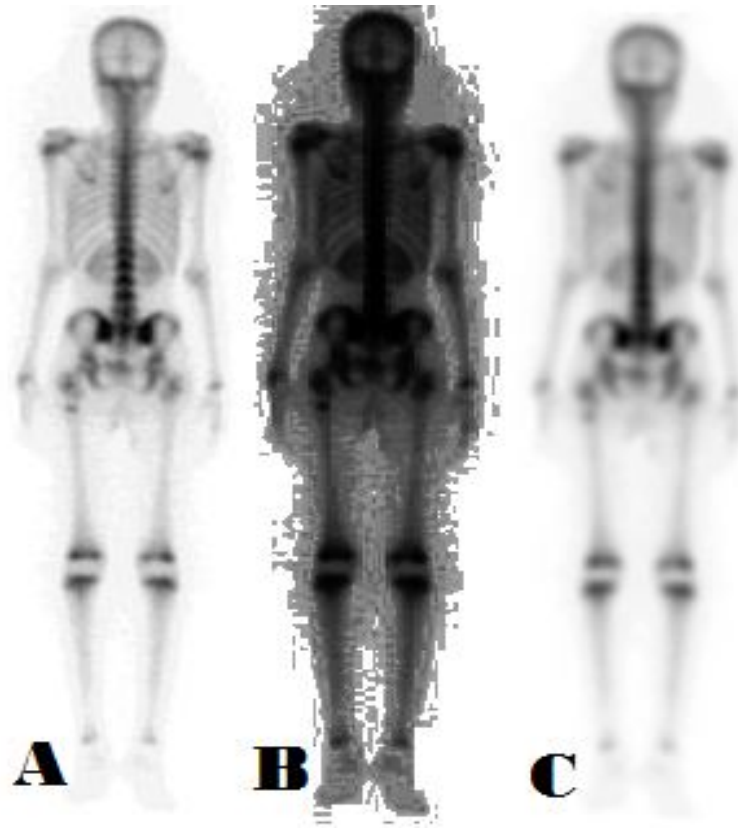
Figure (4.1) demonstrated original images for bone Scintigraphy (A) the original image (B) showed image after Histogram equalization. (C) Showed an image after median filter smoothing.

Figure (4.2) simple error bar demonstrate the difference in SN in Wight area before and after enhancement
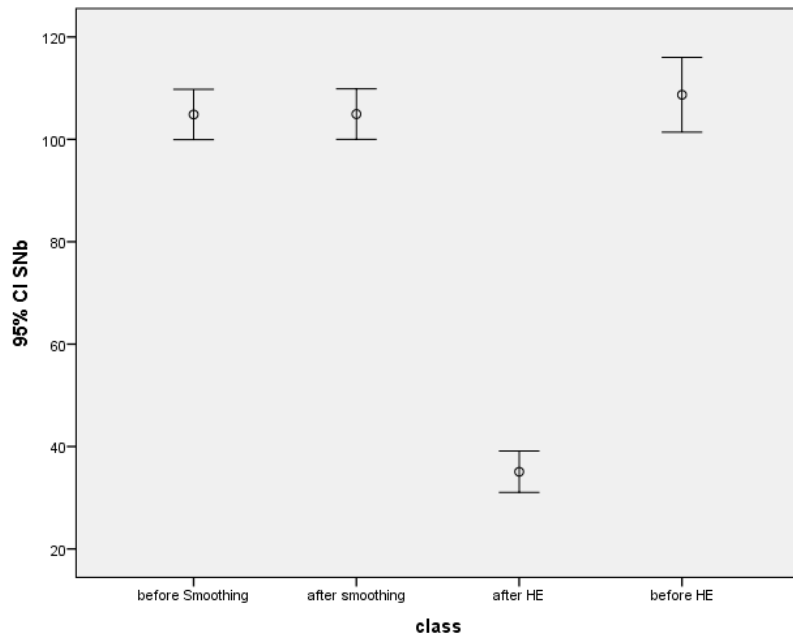
Figure (4.3) simple error bar demonstrate the difference in SN in black area before and after enhancement
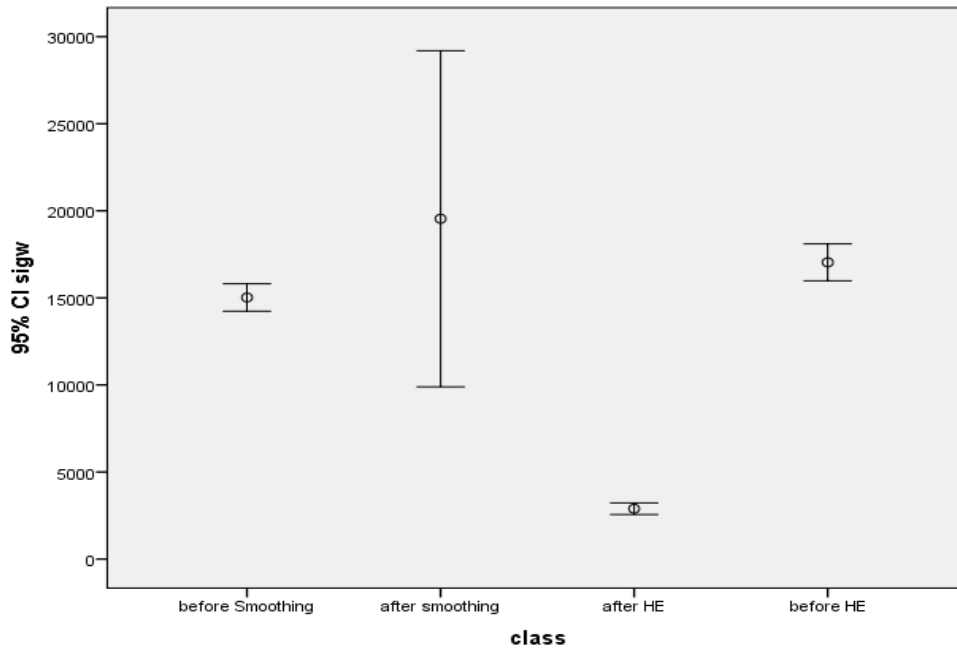
Figure (4.4) simple error bar demonstrate the difference in Signal in Wight

area for both before and after enhancement
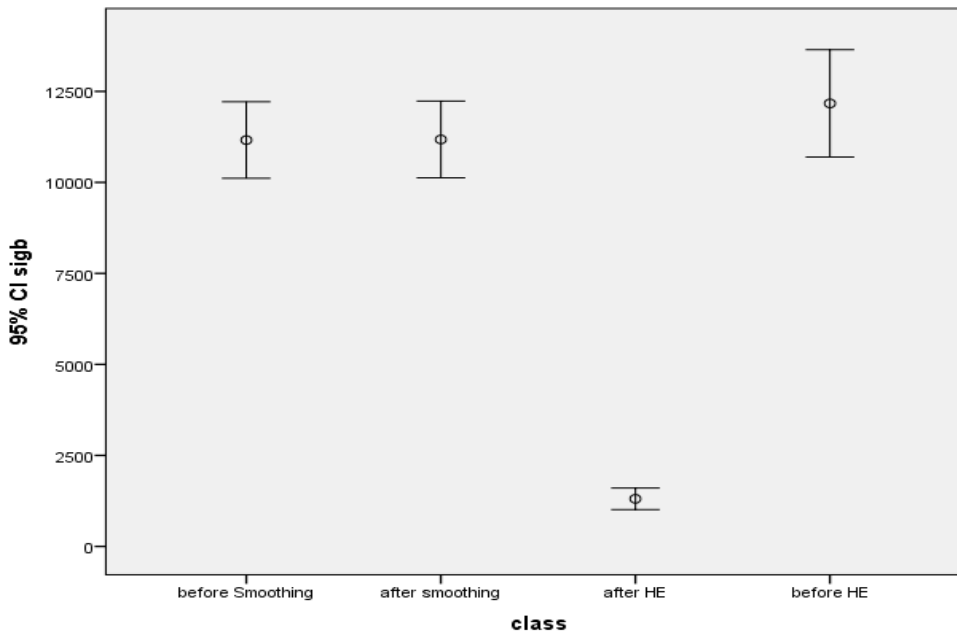
Figure (4.5) simple error bar demonstrate the difference in Signal in black

area before and after enhancement
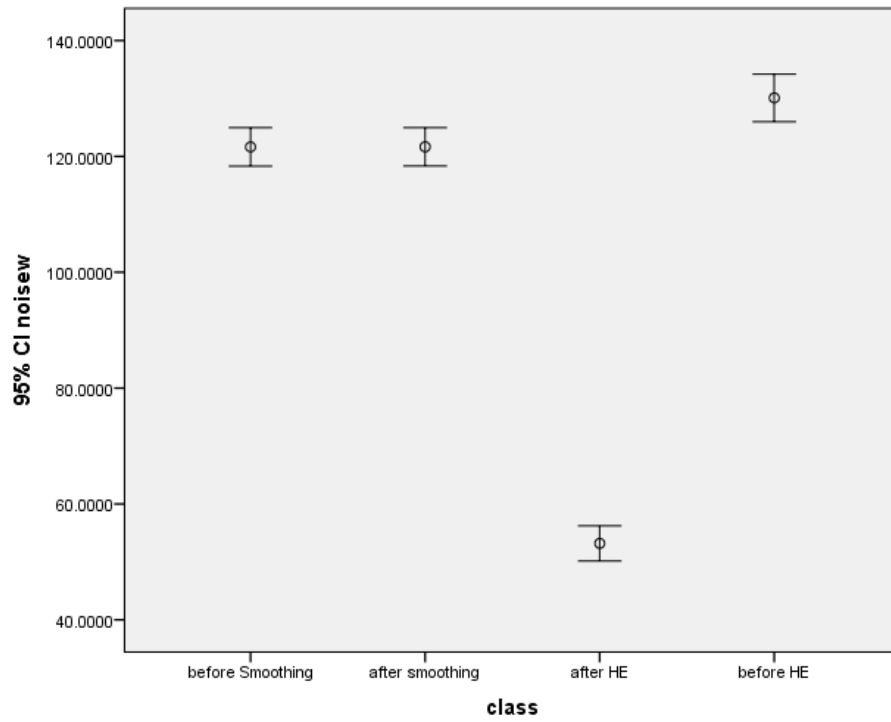
Figure (4.6) simple error bar demonstrate the difference in noise in Wight
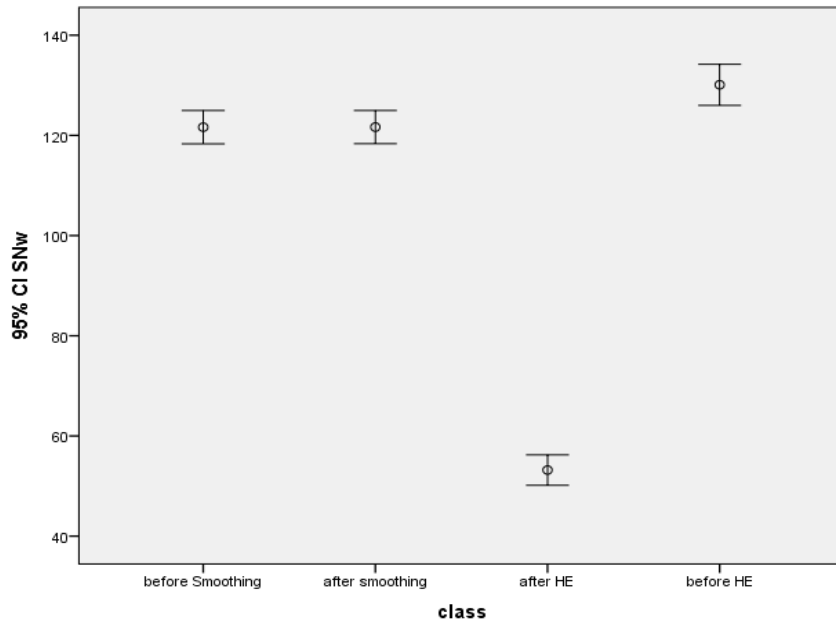area before and after enhancement
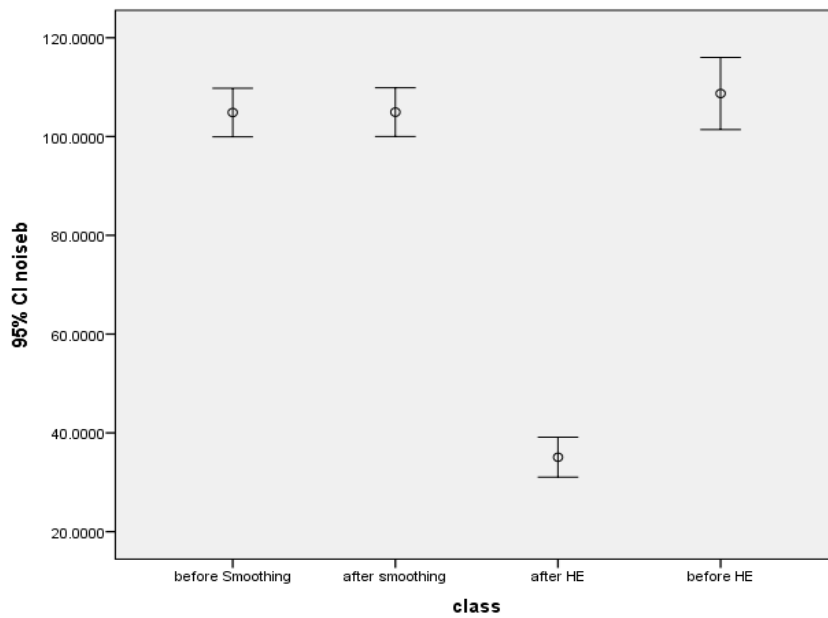
Figure (4.7) simple error bar demonstrate the difference in noise in black area
for before and after enhancement
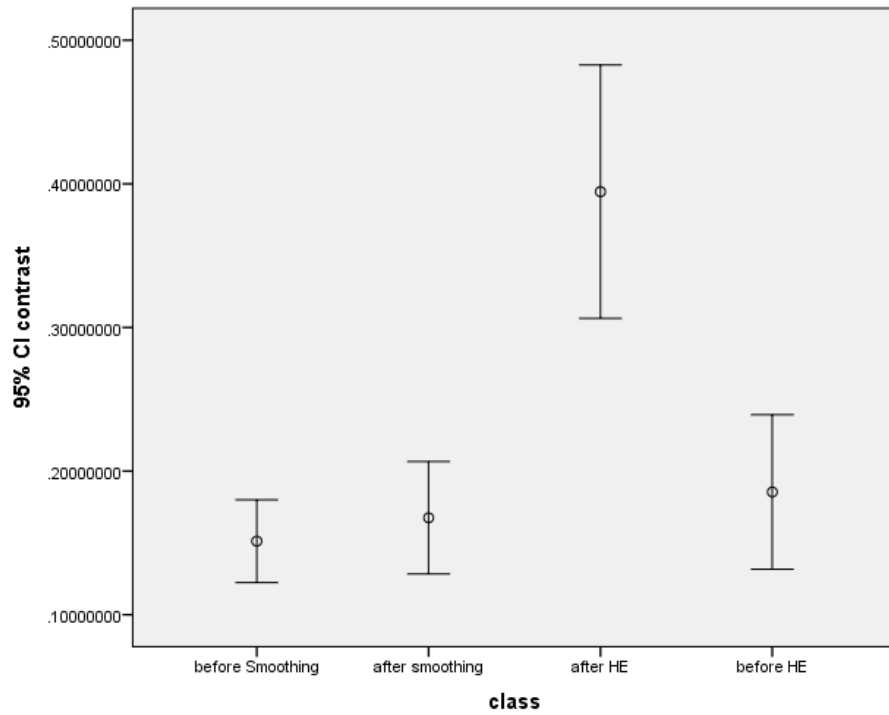
Figure (4.8) simple error bar demonstrate the difference in contrast for both
before and after enhancement
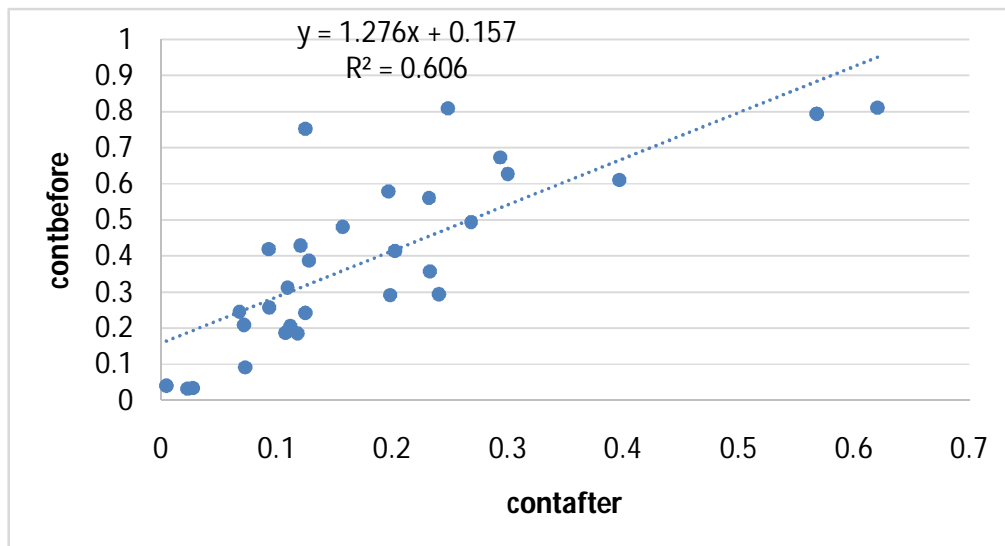
Figure (4.9) Showing the relationship between contrast before and after
enhancement using median filter
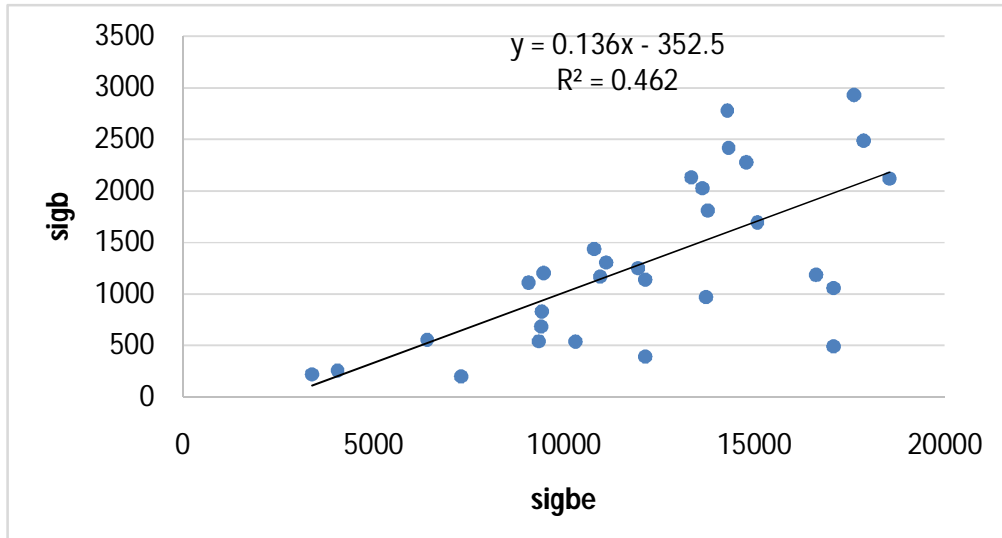
Figure (4.10) showing the relationship between the signal in black area and signal enhancement after using median filter
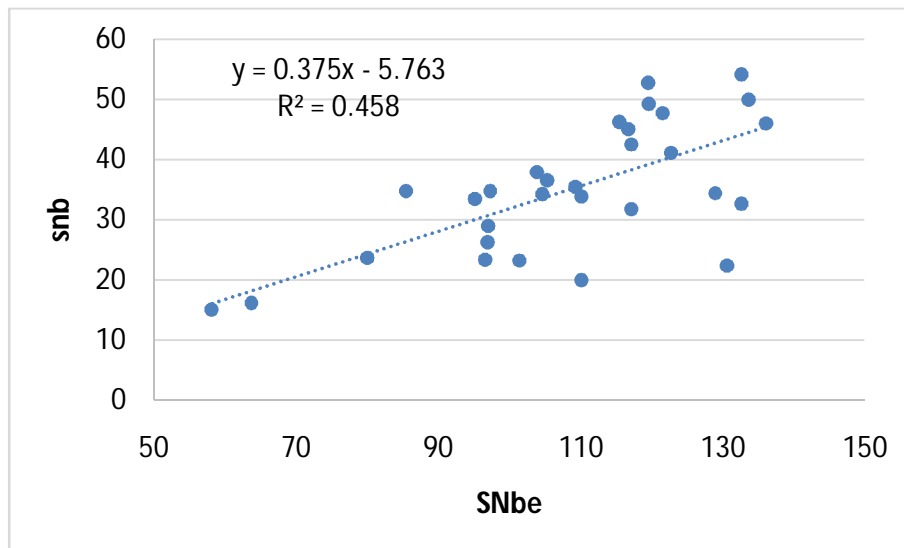
Figure (4.11) showing the relationship between the SNR in black area and SNR enhancement after using median filter.
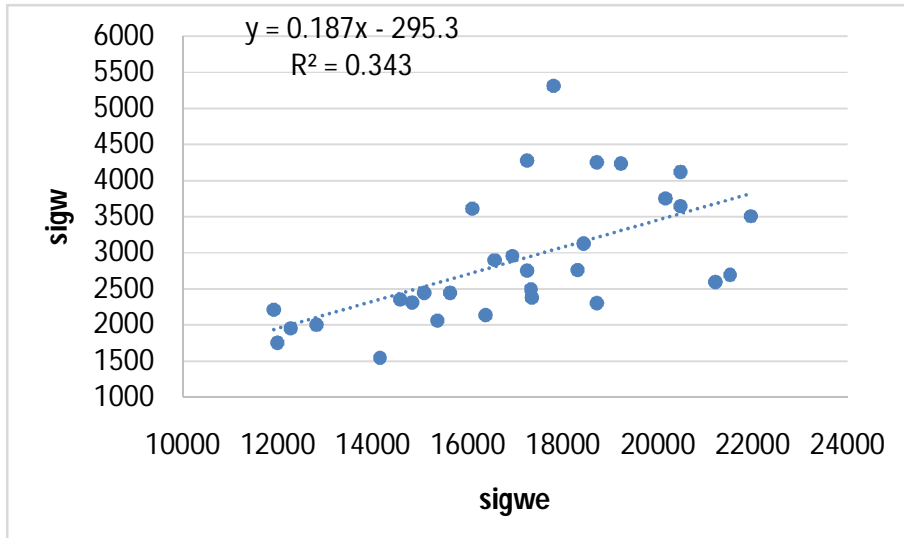
Figure (4.12) showing the relationship between the signal in weight area and signal enhancement after using median filter.
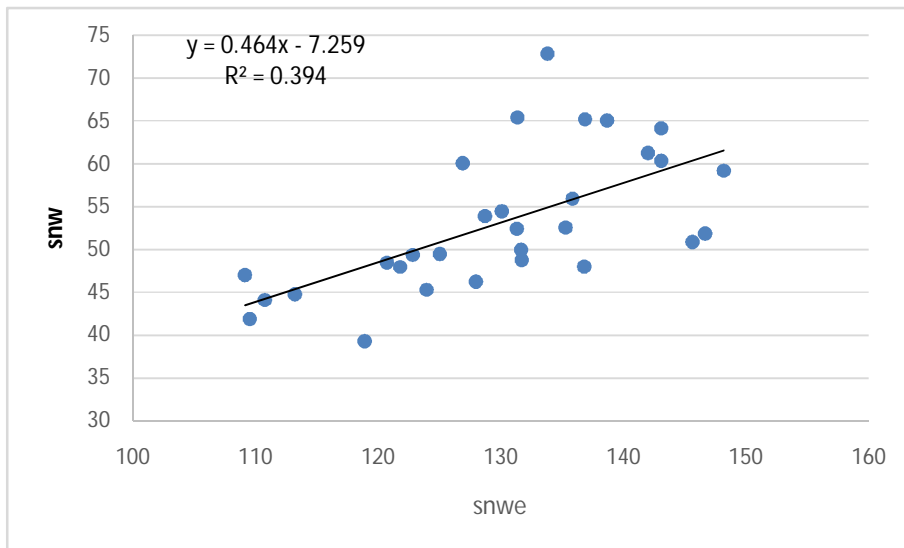
Figure (4.13) showing the relationship between the SNR in weight area and SNR enhancement after using median filter.
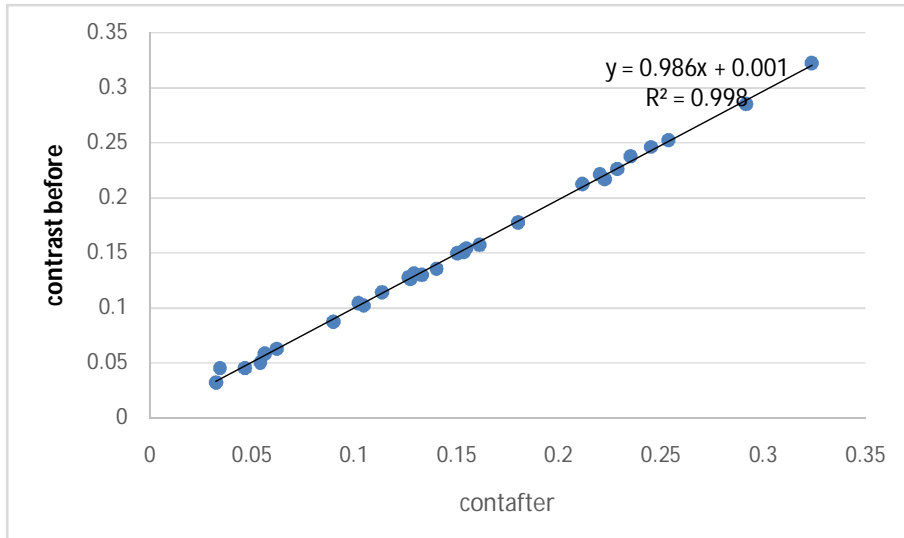
Figure (4.14) Showing relationships between contrast and contrast enhancement after using histogram equalization.
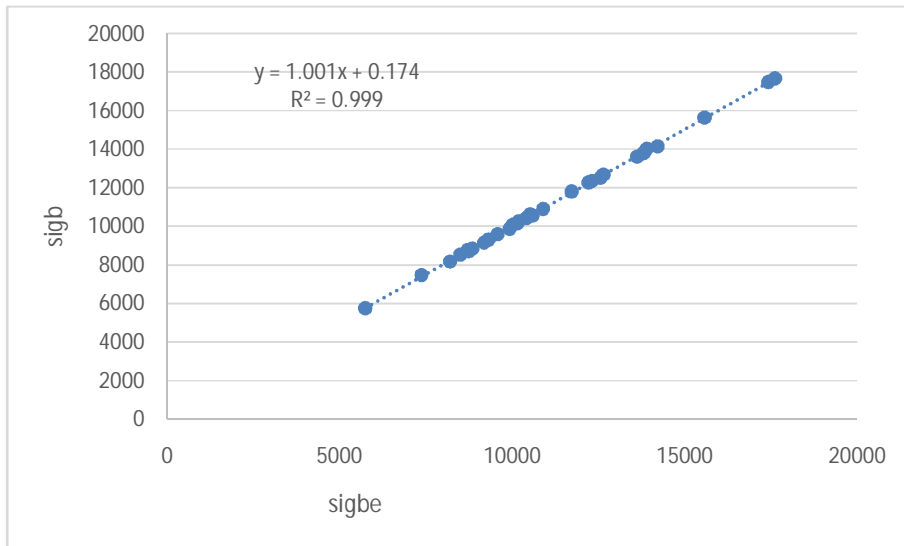
Figure (4.15) showing relationship the signal in black area and signal enhancement after using histogram equalization.
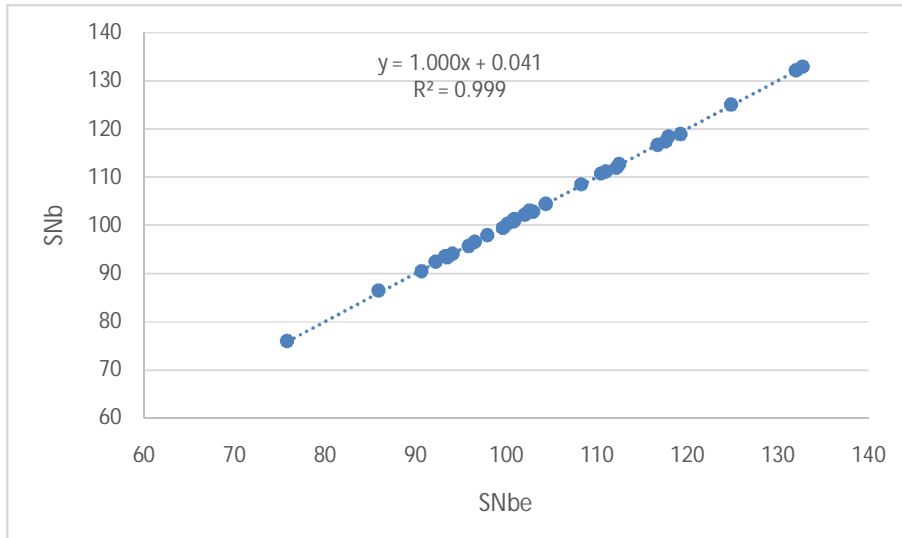
Figure (4.16) showing relationship the SNR in black area and SNR enhancement after using histogram equalization.
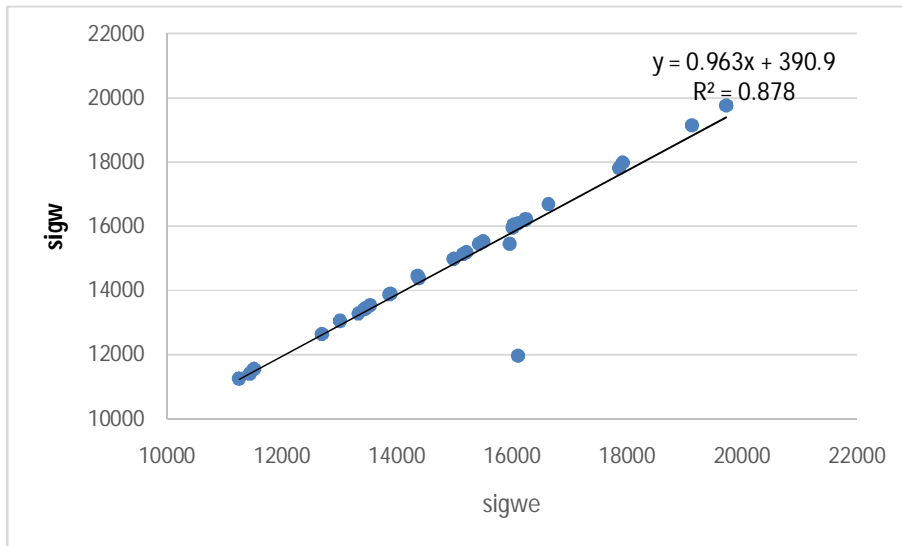
Figure (4.17) showing relationship the signal in weight area and signal enhancement after using histogram equalization.
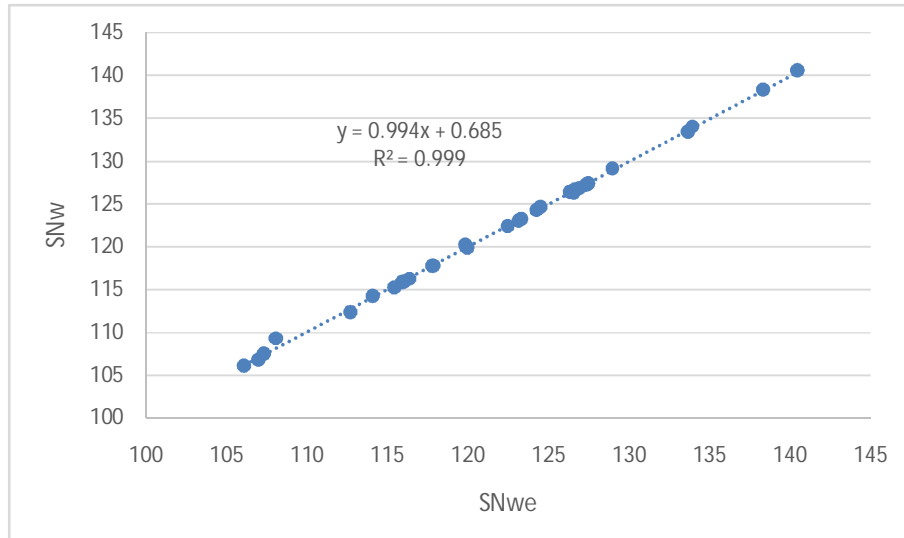
Figure (4.18) Showing relationship the SNR in weight area and SNR enhancement after using histogram equalization.

Table (4.1) Show the mean of the signal , SNR and contrast after enhancement (median filter and HE)

	HE		smoothing	
	black	weight	black	weight
contrast	0.150303		0.372803	
signal	10511.5	15055.5	1178	2639.5
SNR	102.525	122.7	34.56135	51.3737

Chapter five

Discussion, Conclusion, and Recommendations

5.1. Discussion:

Advanced techniques of image processing and analysis find widespread use in medicine. In medical applications, image data are used to gather details regarding the Process of patient imaging whether it is a disease process or a physiological process. Information provided by medical images has become a vital part of today's patient care. This study was intended to enhance nuclear medicine bone for patients undergone bone scan with different pathology to enhance an image and to calculate SNR, in order to have high accuracy in assessing bone disease, preservation of image's overall look; preservation of the diagnostic content in the image and detection of small low contrast details in diagnostic content of the image. Using Interactive data language program (IDL), rather than the use of visual perception of human vision. Data were collected from nuclear medicine department in Fedail hospital, image were selected for IDL analysis after creation of gray scale manner in range of pixel values from 0 up to 255 (0 represent black region- 255 represent white region). Then the program was written for purpose of signal, SNR and contrast calculations in both black and weight area using median filter and histogram equalization which having mean of white and black area; 1178, 34.56135, 2639.5, 51.3737, 0.372803, 10511.5, 102.525, 15055.5, 122.7and 0.150303 respectively.

Classification Map that created using linear discriminate analysis functions where the signal to noise ratio for Wight area before and after enhancements, are clearly separated according to calculated SNR at $P < 0.05$, and CL=95%. there was some similarity noted between SNR before and after smoothing, But after histogram equalization were clearly discriminated as shown in

figure (4-1). The same result with small enhancement has be observed in black area which represented in figure (4-2). While opposite result recorded for signal, where the smoothing produce large discriminate which result in blurring that hidden the details, and histogram equalization with appropriate discrimination suitable to contrast enhancement, this is for Wight area. For black area similarity noted between before and after smoothing recorded and reduced signal after histogram equalization as shown in figure (4-3), (4-4) respectively.

Based on the contrast of an image small enhanced have observed after smoothing, opposite of histogram equalization where large enhancements have been observed represented in fig (4-6). That because when we use the HE function we just distribute the signal again among the peaks and valise in which the intensity was increased and therefore the signal increased.

A correlation was made in order to assess that difference in the measured values for three group (HE, median filter cases and relative to the normal cases) and to find the relationship for each value relative to the normal group of images, Direct relationship between signal in black one before HE as in (x-axis) and after HE (y-axis) in which the signal after HE increased by 1.001 unit for only one unit increased in signal before HE *y=1.001x+0.174, R=0.999,* as in figure 4.15.also direct relationship between SNR in black one before HE as in (x- axis)and after HE (y-axis) in which the SNR after HE increased by 1.00 unit for only one increased in SNR before HE, *y=1.00x+0.041 ,R=0.999* as in figure 4.15. for weight area the signal increased by 1.994 unit for only one unit increased in signal before HE *,y=1.994x-10409,R=0.026,*and SNR increased by 0.994 unit for only one increased in SNR before HE *,y=0.994x+0.685,R=0.999* as I figure 4.17,4.18 respectively.

Direct relationship between signal in black one before smoothing as in (x-axis) and after smoothing (y-axis) in which the signal after smoothing increased by 0.136 unit for only one unit increased in signal before smoothing .*y=0.136x-352.5, R=0462,*as in figure 4.10.also direct relationship between SNR in black one before smoothing as in (x- axis)and after smoothing (y-axis) in which the SNR after smoothing increased by 0.375 unit for only one increased in SNR before smoothing , *y=0.375x-5.763,R=0.458* as in figure 4.11. for weight area the signal increased by 0.187unit for only one unit increased in signal before smoothing ,*y=0.187x-295.3,R=0.343,*and SNR increased by 0.464 unit for only one increased in SNR before smoothing ,*y=0.464x-7.259,R=0.999* as I figure 4.11,4.12 respectively.

For contrast enhancement it inreseased by 0.712 unit for only one increased in contrast before HE, and, by 1.276after smoothing which represented in equations *y=712x+0.059, R=0.276y=1.26+157, R=0.606* as in figure (4.13),(4.14).

5.2 Conclusion:

Nuclear medicine images show characteristic information about the physiological properties of the strcures-organs.in order to have high quality medical images for reliable diagnosis ,the processing of the images is nessecery .The scope of image processing and analysis applied medical application to improve the quality of the acquired image and extract quantitative information from medical image data in an efficient and accurate way.In nuclear medicine there are two main methods of patient imaging ,the imaging with planar imaging ,dynamic imaging or SPECT and PET. In this study analyzed by using IDL program to enhance contrast within bones; the data were collected 30bone images in order to enhance contrast of image and to calculate SNR. the methods for enhancing contrast described here can be used in studies that require wide accurate knowledge of wide range of image processing techniques, especially   .such broad information will be of particular use in have high accuracy in assessing bone disease and detection of small low contrast details in diagnostic content of the image. The result showed that signal after HE increased by 1.001 unit for only one unit increased in signal before HE .as in equation *y=1.001x+0.174,* SNR after HE increased by 1.00 unit for only one increased in SNR before HE, *y=1.00x+0.041 ,R=0.999*, for weight area the signal increased by 1.994 unit for only one unit increased in signal before HE *,y=1.994x-10409,R=0.026*, SNR increased by 0.994 unit for only one increased in SNR before HE *,y=0.994x+0.685,R=0.999*, the signal after smoothing increased by 0.136 unit for only one unit increased in signal before smoothing *.y=0.136x-352.5, R=0462*, SNR in black one before smoothing and after smoothing which the SNR after smoothing increased by 0.375 unit for only one increased in SNR before smoothing , *y=0.375x-5.763,R=0.458*. for weight area the signal increased by 0.187unit for only one unit increased in signal before smoothing

*,y=0.187x-295.3,R=0.343,*and SNR increased by 0.464 unit for only one increased in SNR before smoothing *,y=0.464x-7.259,R=0.999*

5.3 Recommendation:

- Image enhancement is basically improving the interpretability or perception of information in images ' it's important to develop image enhancement program.

- Enhancement algorithm play a critical role in choosing an algorithms for real -time applications despite the effectiveness of each of these algorithms when applied separately ' in practice when has to device a combination of such methods to achieve more effective image enhancement.

- Use image enhancement techniques as pre- processing tools for other image processing techniques' then quantities measures can determine which techniques are most appropriate spatial domain or frequency domain methods.

- Existing technique can be applied to other type of nuclear medicine images.

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Appendix A-1

Row data obtained from IDL program after smoothing

Sigw	noisew	sNw	sigb	noiseb	SNb	contbefor	sigwe	noisewe	snwe	sigbe	noise be	snbe	contafter

Appendix A -2

Row data obtained from IDL program after histogram equalization

sigw	noisew	SNw	sigb	noiseb	SNb	contbefor	sigwe	noisewe	snwe	sigbe	noisebe	snbe	contafter

Appendix -B

Bone scintigraphy image obtained from nuclear medicine department