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Preprocessing Technique for the Enhancement of the Dicom Kidney Images

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Abstract—Automatic diagnostics of kidney carcinoma is one of the most challenging problems in medical image processing as it helps physicians to decide whether a tumor exists or not. So, determining the more efficient methods of detection to reduce the rate of errors is a vital issue among researchers. Preprocessing is the first process of detection to improve the quality of images, removing the irrelevant noises and unwanted parts in the background of the kidney images. The preprocessing process is a vital and important process before our main algorithm (automatic detection for kidney tumors).

Keywords: DICOM, Histogram, Medical Imaging, Computed Tomography (CT), Computer Aided Diagnosis (CAD).

I. INTRODUCTION

At the recent decades the Computer Aided Diagnosis (CAD) becomes very important at the medical diagnosis, the rate for kidney cancer found accidentally is very high because the cancer is usually found at a very early process [1]. In such systems, the Accuracy of diagnostics is not always acceptable and involves some errors. Therefore, high performance Computer Aided Diagnosis (CAD) systems help the physicians to avoid misdiagnosis [2]. This paper propose a preprocessing technique consists of five consecutive steps, firstly read the raw data from the CT scanner ,contrast stretching, removing the noise in order to make all organs are distinguishable, cropping the kidney area(Region Of Interest) from the abdominal image, then we implemented a global enhancement before entering an automatic tumor detection technique ,Since the output of each step is the input of next step, all steps have an important role to avoid misdiagnosis. Preprocessing as the first process of computer aided cancer diagnostics has seriously effects on misleading the results [3].

The datasets were acquired from known scanning center in MANSOURA city and these images are 512 by 512 pixel and these results are obtained using MATLAB R2011b.

II. PROPOSED SYSTEM

Image pre-processing is an essential step of detection in order to remove noises and enhance the quality of original image. It required to be applied to limit the search of abnormalities in the background influence on the result [4]. The main purpose of this step is to improve the quality of kidney carcinoma image by removing unrelated and surplus parts in the back ground of image for further processing. Good selection of preprocessing techniques can greatly improve the accuracy of the system [5][6]. In the present work the objective of the preprocessing process can be achieved through three main processes, process of stretch the contrast the second process is a noise removal and the third is global enhancement (after cropping the kidney area R.O.I). Here, the paper explains above techniques clearly for researchers who involve in preprocessing process of automatic detections.

The total framework of proposed system followed in the preprocessing process of medical image processing is illustrated in the following section which consists of five major steps .The first step is a demonstration for the raw data which extracted from the C.T scanner then read it by MATLAB function, the second sup step is a contrast stretching of the image, the third part is the noise removal by a convenient technique. The fourth part is cropping the abdominal image by a predetermined coordinates to extract the kidneys, and last step is a global enhancement which make another data stretching before entering to the main algorithm (Automatic Tumor Detection).As shown in figure 1 the complete algorithm is shown in **Fig. 1**, the first process (preprocessing) illustration with its major steps.

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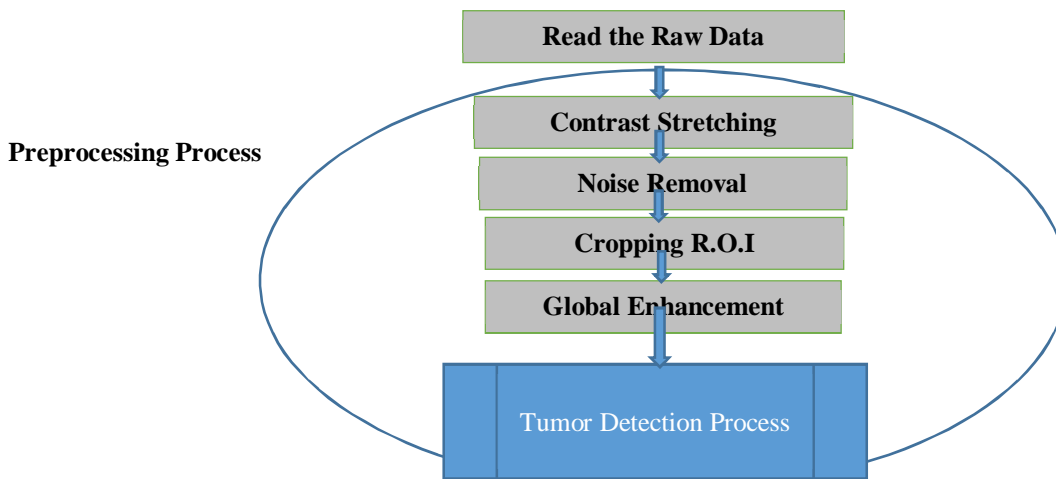


Fig. 1: Complete Flow Chart

A. Read The Raw Data

Digital Imaging and Communications in Medicine (DICOM) is a standard for handling, storing, printing, and transmitting information in medical imaging. It includes a file format definition and a network communications protocol. [7], we use the command (`dicomread`) to read the image data and handle it using MATLAB.

The most common problems at DICOM was 1-the poor contrast of images, 2- Gaussian and speckle noise [8][20] as shown at Fig. 2 the raw data and the histogram of the raw data shown that the contrast levels are concentrated at the middle of range of values. so we start the preprocessing operation by adjusting and stretching the contrast and remove the expected noise as we will mention.

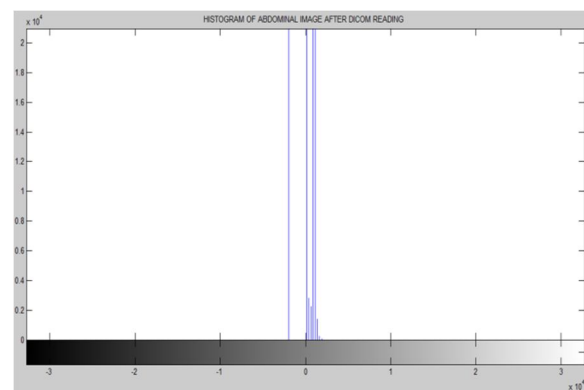
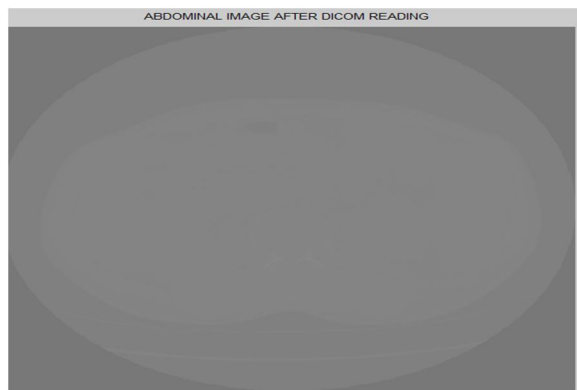


Fig.2: (a) Raw Data

(b) Histogram of Raw Data

As we can see from Fig.2 the raw data has a poor contrast and the histogram is very narrow, it reflects the poor vision of the machine and human also.

B. Contrast Stretching

Contrast enhancement is beneficial step to improve the perception for further processing; it can sharpen the image border and improve the accuracy by accentuating the brightness difference between background and foreground. Contrast enhancement plays a vital role in increasing the quality of an image [9]. Contrast stretching is one of the image enhancement technique that is commonly used for medical images and attempts to improve the contrast in an image by stretching the range of the intensity values it contains to span a desired range of values. The full range of pixel values that the image type concerned allows Contrast Stretching changes

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the distribution and range of digital numbers assigned to each pixel in an image. Contrast stretching process plays an important role in enhancing the quality and contrast of medical images.[10][11]_ We must redistribute the brightness levels to make a clear distinguish between the tumors and the healthy tissues before detecting the edges, As we can see from the following figures Fig. 3, Fig. 4 and Fig. 5 we will adapt the histogram manually, by applying the command (imcontrast) which adjust the contrast as the following .

imcontrast(h) (h) is the target image (1)

This command creates an Adjust Contrast tool in a separate figure that is associated with the grayscale image in the current figure, called the target image. The Adjust Contrast tool is an interactive contrast and brightness adjustment tool, shown in the following figure that you can use to adjust the black-to-white mapping used to display the image .[12]

After applying the tool and as it's clear from the following figures the curve consists of two peaks, we will remove the undesired area and choose the region of interest (R.O.I). we will take the two levels ((Max , Min) ,substitute at the algorithm as a default values. [.63 .78] , the impacts of two peaks values manual adjustment are shown below in Fig. 3, Fig. 4 and Fig. 5 then get the best result at Fig. 6.

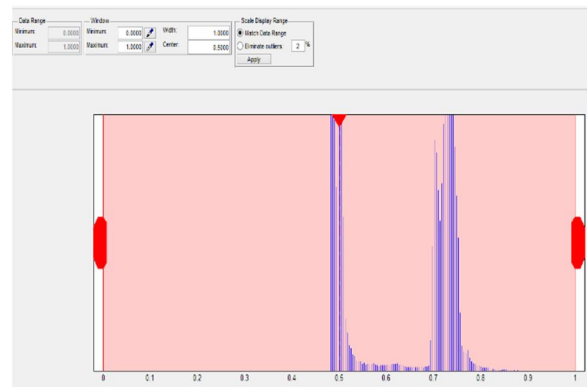
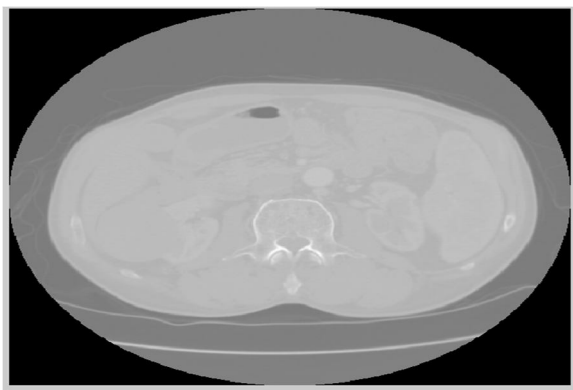


Fig. 3: (a) Abdominal Image after applying the command imhist

(b) Histogram Of Image after applying the command imhist

As shown at Fig .3 the abdominal image is still has a poor contrast and the histogram starts to stretches but within limited two peaks which reflect a bad visualization

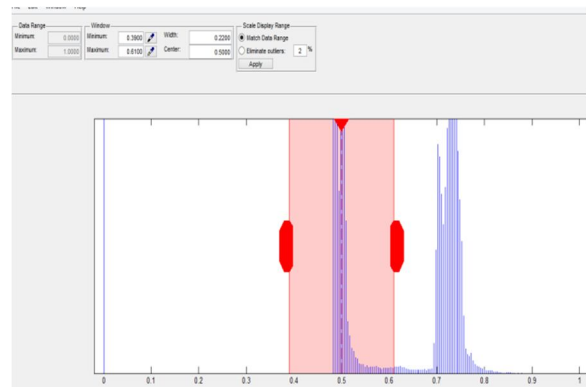
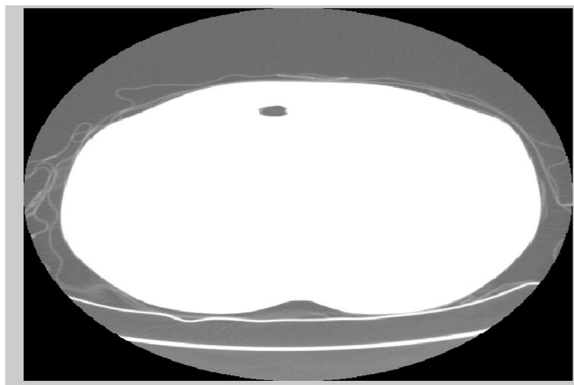


Fig.4: (a) Abdominal Image After Choosing The Lower Region

(b) Histogram of Image After Choosing The Lower Region

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As shown from the Fig.4, by using an interactive selective region function (imhist), this region of contrast (.4 to .6) has no useful data for our main task (kidney extraction).

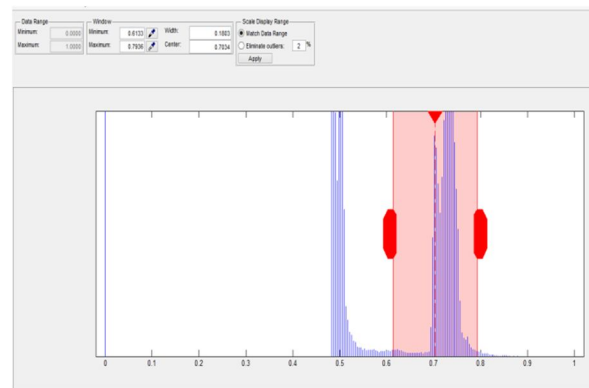
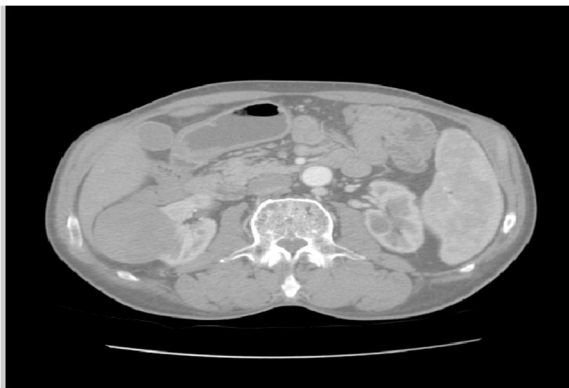


Fig.5: (a) Abdominal Image after Choosing the Upper Region

(b) Histogram Of Image After Choosing The Upper Region

As shown from Fig.5, by choosing the upper region, this range of brightness levels from [.63 .78] has the useful data for our main task (kidney extraction). From the Fig.3, Fig. 4 and Fig. 5 we will implement the data stretching task by using the command (imadjust), (imadjust) adjust image intensity values as the following.

$$J = \text{imadjust}(I, [\text{low_in}; \text{high_in}], [\text{low_out}; \text{high_out}]) \quad (2)$$

(imadjust) maps the values in I to new values in J such that values between low_in and high_in map to values between low_out and high_out. Values for low_in, high_in, low_out, and high_out must be between 0 and 1. Values below low_in and above high_in are clipped; that is, values below low_in map to low_out, and those above high_in map to high_out. You can use an empty matrix ([]) for [low_in high_in] or for [low_out high_out] to specify the default of [0 1][12]. By entering the two brightness levels (.63 .78) as a Min & Max default intensity [In] values.

The command (imadjust) stretches the input selective brightness levels of (R.O.I) to (0 1) which represent the upper region of the histogram Fig.4, Fig.5 and Fig.6. The results after applying this command and the histogram are shown at Fig.6.

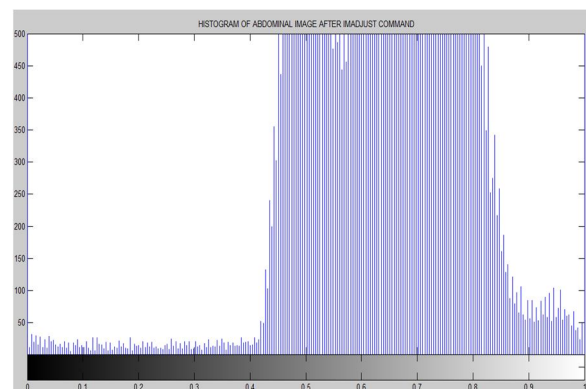
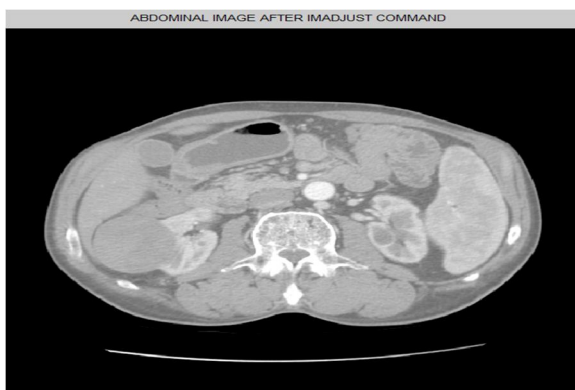


Fig.6: (a) Abdominal Image after Stretching by (imadjust)

(b) Histogram of Abdominal Image After Stretching by (imadjust)

From Fig.6 the abdominal image looks clear, the edges are more detectable and the histogram is more stretched than before.

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C. Artifacts And Noise

Artifacts are commonly encountered in clinical computed tomography (CT), and may obscure or simulate pathology. There are many different types of CT artifacts, including noise, beam hardening, scatter, pseudo enhancement, motion, cone beam, helical, ring, and metal artifacts. Methods for reducing noise and out-of-field artifacts may enable ultra-high resolution limited-field-of-view imaging of tumors and other structures [16]. Aim of the preprocessing process in this paper for correctly automatic detection the kidney tumor (if it was) by an ultimate precision. Poisson noise is due to the statistical error of low photon counts, and results in random thin bright and dark streaks that appear preferentially along the direction of greatest attenuation [16]. But the most common noise at CT scanner was the Gaussian noise [17] [18] and Speckle noise which is mostly detected in case of CT images. [20]

D. Noise Removal

Noise Removal is defined as the procedure to recover the degraded image from a blurred and noisy one. It can restore the degraded images in different ways. The image degradation can happen by various defects such as imperfection of imaging system, bad focusing, motion and etc. which make an image usually noisy or blur. Since the corrupted images lead to fault detection, hence, it is essential to know about noises present in an image to select the most appropriate de-noising algorithm [13] [14]. Image de-noising is an essential step in preprocessing of an image. It is extremely difficult to apply an effective de-noising algorithm for different types of noisy images. The essential property of a good image de-noising method is to suppress the noise as well as preserving the edges [15].

1) *Gaussian Filter*: Gaussian filtering is done using masks of odd size. Each point of the mask has a value computed from a function that expresses the Gaussian distribution. In one dimension, the continuous Gaussian function (centered at $x = \mu$) is

$$g(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2} \quad (3)$$

Where x is the location of the filtered point, (μ) is mean and (σ) is standard deviation. In two dimensions, the continuous Gaussian function (centered at (μ, σ)) is

$$f(x, y) = \frac{1}{2\pi\sigma^2} e^{-((x-\mu_x)^2 + (y-\mu_y)^2) / (2\sigma^2)} \quad (4)$$

Where (x, y) is the location in 2D of the filtered point. Since the filtering is done using a mask, the weights are found using row and column coordinates (with respect to the pixel points) as the x and y inputs in Equation 2-4. (17)

2) *Wiener*: To introduce Wiener filtering, we shall discuss a more general question: given a degraded image M' of some original image M and a restored version R what measure can we use to say whether our restoration has done a good job? Clearly we would like R to be as close as possible to the 'correct' image M . One way of measuring the closeness of R to M is by adding the squares of all differences:

$$\sum ((m(i, j) - r(i, j)))^2 \quad (5)$$

m : pixel of original image, r : pixel of image after filtering

Where the sum is taken over all pixels of R and M (which we assume to be of the same size). This sum can be taken as a measure of the closeness of R to M . If we can minimize this value, we may be sure that our procedure has done as good a job as possible. Filters which operate on this principle of least squares are called Wiener filters (19).

3) *Metrics And Results*: We will compare by a (HVS) Human Visual System and by quality metrics (MSE, PSNR) the different methods between the most efficient filters, which designed for Gaussian and speckle noise the Wiener filter [3x3], Wiener filter (5x5) and median filter to get the best performance, the equations of quality metrics are shown below then the comparison images for three filters at **Fig.7, Fig.8, Fig.9** and **Fig.10**, then the quality metrics table (I).

$$MSE(X) = E((X - \mu)^2), \quad X = \text{expected value}, \mu = \text{The mean value} \quad (6)$$

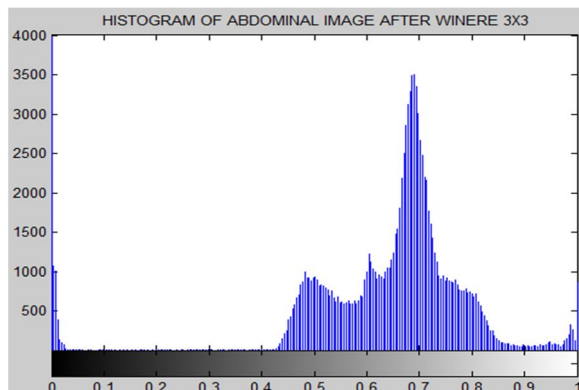
$$PSNR = 10 \log \frac{MAX I^2}{(MSE)} \quad I = \text{max of pixel value} \quad (7)$$

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As shown at Fig.7 the image is clear, the edges are detectable and the histogram has one peak concentrated around [.6 .8] and



Fig.7: (a) Abdominal Image Filtering by Winner 3X3



(b) Histogram Of Abdominal Image Filtering by Winner 3X3

distributed from [.45 to1] .

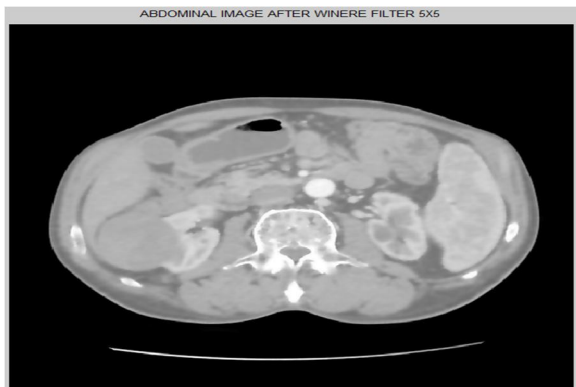
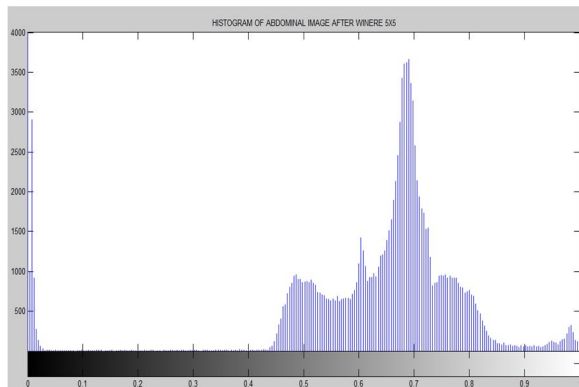
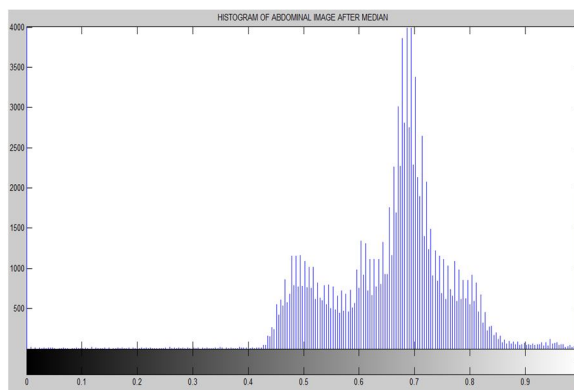


Fig.8:(a) Abdominal Image Filtering by Winner 5X5



(b) Histogram Of Abdominal Image Filtering by Winner 5X5

As shown at Fig.8, (the image is blurred, the edges are not detectable as winer 3X3 but the histogram seem identical to the winer 3X3

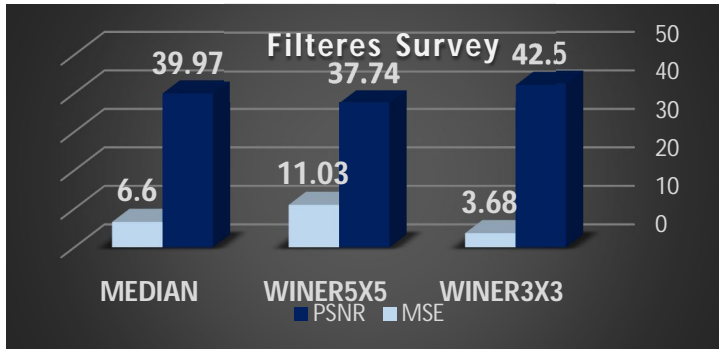


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Fig.9: (a) Abdominal Image Filtering by Median Filter

(b) Histogram of Abdominal Image Filtering by Median

As shown at Fig.9 to the median filter the image is clear, the edges are detectable and the histogram has one peak concentrated around [0.6 0.8] and distributed from [0.45 to 1]



NO	FILTER	MSE	PSNR
1	WINER3X3	3.68	42.5
2	WINER5X5	11.03	37.74
3	MEDIAN	6.6	39.97

Fig.10 Comparison between Filters

As we saw from the Table.1 and the previous Fig.7, Fig.8, Fig.9 and Fig.10 we selected winer (3X3) for the following reasons:
 the clearer image by using (HVS) Human Visual System.
 the best performance (biggest PSNR value) and (lowest MSE value).
 the most detectable edges.

E. Cropping (R.O.I)

Firstly we will crop the images by a predetermined coordinates for every CT slice, to extract the kidneys from the abdominal images. The cropping results illustrated at Fig.11 and Fig.12.

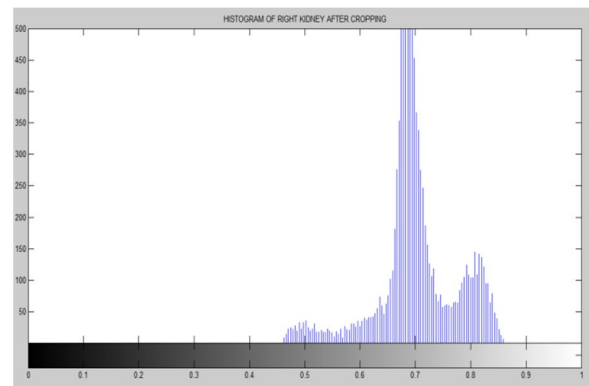


Fig.11: (a) Right Kidney after Cropping Step

(b) Histogram of Right Kidney after Cropping Step

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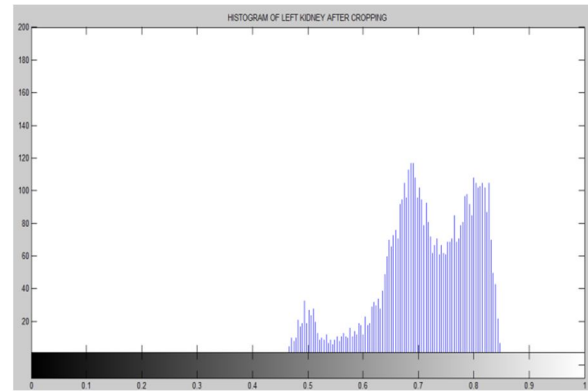


Fig.12: (a) Left Kidney after Cropping Step

(b) Histogram of Left Kidney after Cropping Step

from the figures of right and left kidney (which is bad contrast) and the histograms (which is narrow), We have to make a global enhancement to view the images with clear details, and more detectable edges, we will choose a command rely on a comparison between three of MATLAB commands to achieve the best results as we will explain at the next step.

F. Global Enhancement

MATLAB has three functions for contrast enhancement and stretching (`imadjust`), (`histeq`) and (`adapthisteq`), we compared between the three functions and their results which illustrated at Fig.13, Fig.14, Fig. 15, Fig.16, Fig.17 and Fig.18, We will rely on the (HVS) Human Visual System to select the best results, the three commands function explanations are shown below.

(`imadjust`): mentioned before

(`adapthisteq`): Contrast-limited adaptive histogram equalization (CLAHE), CLAHE operates on small regions in the image, called *tiles*, rather than the entire image. Each tile's contrast is enhanced, so that the histogram of the output region approximately matches the histogram specified by the 'Distribution' parameter. [12]

(`histeq`): enhances the contrast of images by transforming the values in an intensity image, or the values in the color map of an

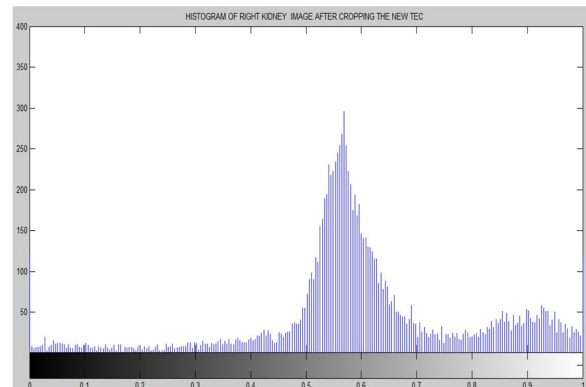


Fig.13: (a) Right Kidney After `imadjust` indexed image, so that the histogram of the output image approximately matches a specified histogram.[12]

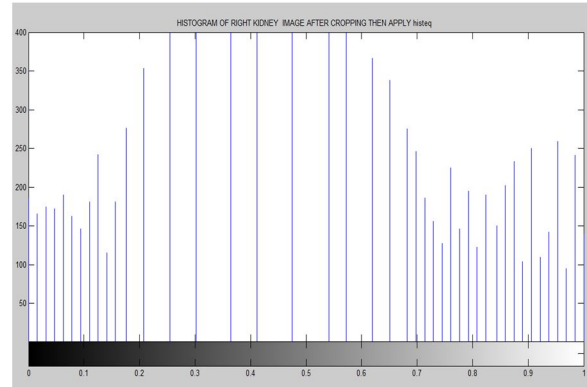
(b) The Histogram of Right Kidney After `imadjust`

III. RESULTS

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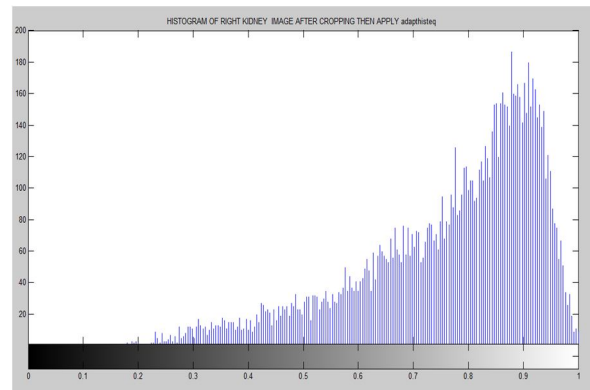
Fig.14: (a) Right Kidney After histeq



(b) The Histogram of Right Kidney After thisteq



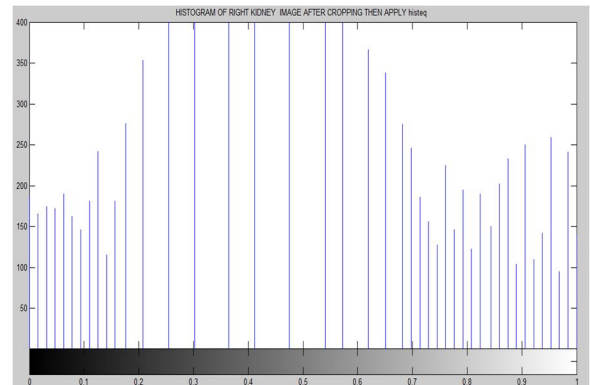
Fig.15: (a) Right Kidney After adapthisteq



(b) The Histogram of Right Kidney After adapthisteq



Fig.16: (a) Left Kidney After imadjust



(b) The Histogram of Left Kidney After imadjust

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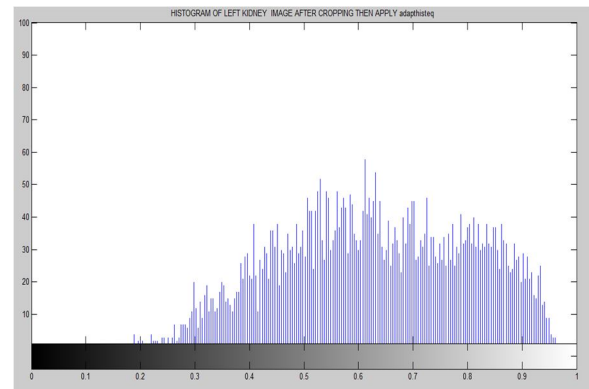
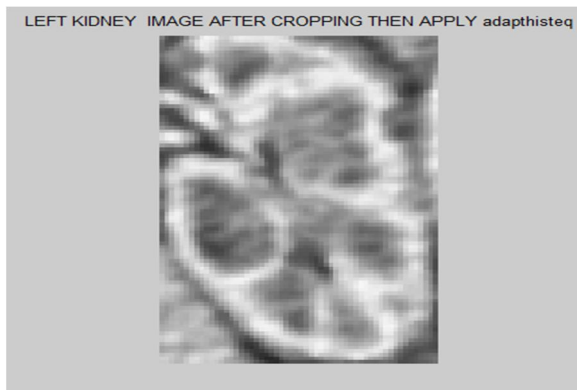


Fig.17: (a) Left Kidney After adapthisteq

(b) The Histogram of Left Kidney After adapthisteq

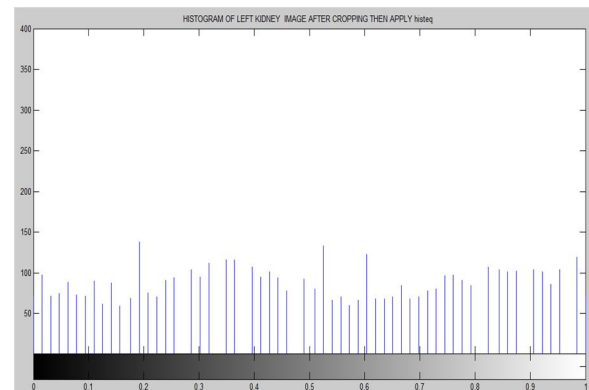


Fig.18: (a) Left Kidney After histeq

(b) The Histogram of Left Kidney After histeq

To implement the global enhancement step we selected the command (imadjust) because of the following reasons:
The clearest vision for both kidneys by using (HVS) Human Visual System
The most detectable edges
High performance detection rate from the results of the following process (automatic kidney tumor detection)

IV. CONCLUSION

This paper presents an important process before a fully automatic tumor detection technique, this process is a preprocessing process which consists of consecutive five steps, by using MATLAB R 2011b, We used the functions (dicomread), (imadjust), winer filter 3X3 and (imadjust) to stretch the contrast, noise removing and make a global enhancement. The preprocessing process is contributed in improving a quality of these images, by using quantitative parameters like PSNR, MSE and naked eye HVS. It has been found that the proposed method performs better than all other methods while still retaining the structural details.

V. FUTURE WORK

In the future we will develop an algorithm for kidney segmentation also tumor detection, analyze and classify the type of tumor.

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