

A Robust Adaptive Wiener Filtering Method for High-Quality Medical Image Enhancement

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Abstract

The process of image enhancement considered as an important and a complex mechanism in the field of medical image processing, these techniques are applied for the purpose of making the visual appearance of images acceptable. There are many problems suffered by medical images of all kinds, such as noise in addition to poor contrast. Noise in medical images occurs due to acquisition, transmission, reception as well as storage and retrieval. This results in poor image quality, so the importance of the noise removal process appears in order for the image to be ready for use for medical purposes, which include diagnosing diseases . In this research, a very effective method has been introduced by using an important and effective noise-cancelling filter, the Adaptive Wiener filter. In order to measure the performance of this filter two parameters are used peak signal to noise ratio (PSNR) and mean square error (MSE). The results obtained in this method were excellent, as they demonstrated the effectiveness of the filter that was used.

Keywords : Image Enhancement , Medical Imaging , Adaptive Wiener Filter , Image De-noising .

1. Introduction

Medical imaging has become one of the very important criteria for the process of diagnosing diseases in addition to the process of medical intervention for the purpose of visual representation of the function of tissues and organs. The availability of imaging has increased significantly in addition to the great use of it in the field of modern medicine, which includes (MRI) and (CT)), this increase led to the emergence of an urgent and actual need for the processing of scanned medical image data automatically[1]. Most of the medical images taken are often by X-rays, magnetic resonance imaging, Computed radiography, as well as CT scans, these images suffer from types of noise such as salt and pepper noise and Gaussian noise, which have a significant impact on the quality of the image, resulting in a significant deterioration in CAD[2]. Medical images play a major and important role in the process of treating the patient, as these images illustrate the tissues as well as the various parts of the human body. Therefore, it has become necessary to improve medical images to help doctors make the correct diagnosis and give appropriate treatment[3]. The final outcome in improving the medical image is to obtain a clear interpretation of the information in the medical image by humans or to obtain accurate features by methods that are assisted by machine learning. These images, which have been improved by adjusting the density of the image element (pixels) by performing nonlinear transformations, are considered in terms of quality to be much better than the original image[4]. The process of choosing the appropriate enhancement technique must be chosen based on the uniqueness and problems in the medical images because each case may require a different method and technique [5]. This paper is organized as follows: Section 2 describes the related work. Section 3 explains medical image enhancement, Section 4 describes image filtering. Section 5 introduces the proposed method .Section 6 deals with the experimental results. Finally ,Section 7 discusses conclusion of the paper.

2. Related Work

The process of improving the medical image by removing noise is a very important process in order to obtain clearer medical images.[6] Introduced a study, that aimed to improve the image of the optic nerve head that was previously acquire by (OCT). Here, multiple and advanced methods were used ,Super -Resolution techniques .The method of Super -Resolution, an image that has a low resolution will be enlarged to match the size of another image that has a high resolution. Regarding the image enhancement process in this case, the enlarged image with low resolution have low quality and is a distorted image. As for the other image with high quality, it is considered the improved version that is intended to be obtained. .[7] proposed an image enhancement method using two approaches : The first approach is done by sequentially activating the hybrid neural network based on the correlation geometry within the different and complex levels of the image. The second method is through arranging the geometric gradient vectors of the image element (pixels). By organizing the proposed MHNNs, this will be achieved. Here, they will act as an extraordinary filter for the spectral sequences of the image element (pixels). Here, the focus is on both global and local improvements to achieve the correlation of features in each sub-area of the image, resulting in an enhancement of resolution, contrast, information content, and edges.[8]] In this paper Hexagonal Gabor filters (HBF) are used to enhance fingerprint images, enabling two main operations: image enhancement during preprocessing and interpolation. Because of these advantages, many researchers have explored the possibility of using hexagonal structure to represent digital images.[9]presented a paper reviews a fuzzy enhancement technique based on neural networks. a Wiener filter, is used for Image preprocessing ,while enhancing the contrast is performed by using Local Transform Histogram (LTH). Next, a fuzzy boosting technique based on neural networks is applied, which includes three main stages: fuzzing , membership function application, and defuzzification.[10] This study presented an improved technique to improve the quality of medical images. This technique relies on three different optimization steps. It begins by using the Unsharp Masking (USM) method to enhance sharpness, the results of which are fed to a logarithmic transformation (LT), and then the output of the logarithmic transformation is passed to the Adaptive Histogram Equalization (AHE) technique.

3. Medical Image Enhancement

Medical images are an important source of information that doctors need to diagnose diseases and make appropriate treatment decisions. The diagnosis process relies heavily on visual perception of the image [11]. Image enhancement is a process that aims to remove noise from images, increase their brightness, or enhance their sharpness to clearly illustrate the main features of the image. To achieve this, various contrast enhancement techniques are used [12].The enhancement of medical image is a difficult matter in image processing, that is related to low quality of the resulting images after acquisition or transmission greatly affects observation and clinical diagnosis[13]. The key of the process for enhancement the image is to present it more clearly and appropriately compared to the original image [14]. Enhancement process does not increase the information content of the data, but rather expands the dynamic range of the selected features so that they become more visible and easily detectable [15].

4.Filtering Techniques

4.1 Median filter

The median filtering, which is similar to process of convolution, is a process that depends on the neighborhood, but in this case the weighted sum is not calculated, rather, it arranges the pixels that are located within the surrounding area based on their gray values, and then the sorted median value is determined, and here the central pixel is replaced by this value in the area adjacent to the output[16].

4.2 Wiener filter

In 1940 Nobert Wiener proposed the Wiener filter and it published in 1946, The primary purpose of Wiener filter is removing noise from signal. Noisy images (when a known low-pass filter is passed) can be restored using inverse filtering. In order to improve the restored image, Wiener filtering strikes a perfect balance between inverse filtering and noise smoothing. One of the most important features is reducing the MSE between the estimated image and the desired image, and this reduces the total square error during the inverse filtering and noise smoothing process[17].

4.3 Adaptive Wiener Filter

The Adaptive Wiener filter regulate or adapt the filter's output based on the local variance of the image. The main important goal of this filter is minimizing the mean square error (MSE) between the enhanced image and the original image[18].

5. Proposed Methods

In this work an effective enhancement method proposed for medical images based on using Adaptive Wiener Filtering. This method consist of multiple stages, first a colored medical image will be read from images database, then the input colored image is resizing into suitable size for process acceleration. After that the color image will be converted to grayscale image. In order to obtain noisy image a Gaussian noise will be added to grayscale images, at end an Adaptive Wiener filter applied for image enhancement. The enhancement method illustrated in block diagram as shown in figure (1):

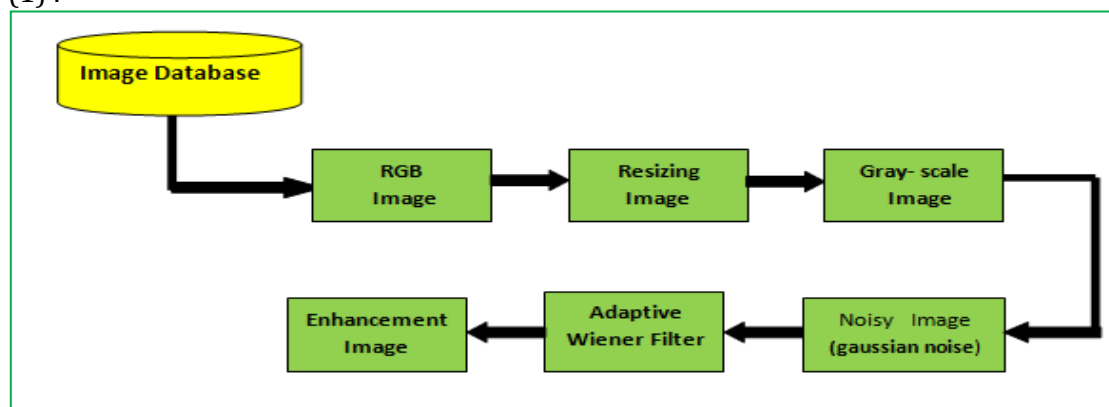


Figure (1) : Block diagram for the proposed enhancement method

5.1 Medical Image Database

A database was created containing a number of color medical images of varying sizes that were taken from the web, a medical images database shown in figure (2):

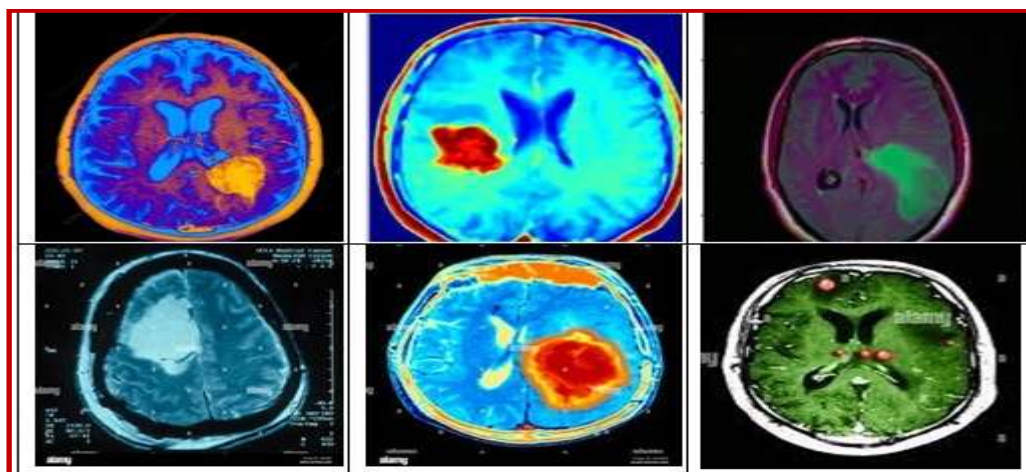


Figure 2 : The database of medical images

5.2 Image resizing

The size of the images being read from the database has been modified to (250 x 250) pixels. The process of reducing the image size for the purpose of reducing the time required for the enhancement and noise removal process.

5.3 Color image conversion

In order to convert the color medical image to a grayscale image, the following equation that converts RGB values to grayscale values by create a weighted sum of the R, G, and B components as shown in equation(1):

$$Y = 0.2989 * R + 0.5870 * G + 0.1140 * B \quad \dots (1)$$

5.4 Noise image

Gaussian noise is added to grayscale image in order to produced noisy image, Gaussian noise is statistical noise, it's known as Gaussian white noise, and is characterized by a probability density function(pdf) of a normal distribution. When this noise added to the original image. The probability density function(P)of the Gaussian random variable(z) is calculated as in equation (2):

$$PG(z) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(z-\mu)^2}{2\sigma^2}} \quad \dots (2)$$

Where :

z : represents gray level

μ : represent the mean value

σ : the standard division

5.5 Adaptive Wiener Filter

A (wiener2) function in MATLAB was used for the purpose of removing noise and enhancing the medical image. The Wiener filter adapts itself to the local contrast of the image. It performs little smoothing when the variance is large and more smoothing when the variance is small. The (wiener2) works well with additive, constant-energy ("white") noise, such as Gaussian noise.

6. Experimental Results

The proposed enhancement method based on Adaptive Wiener Filter has been implemented with MATLAB software . At the first step, colored medical image was

reading from the image's database, after that it resized into suitable size ,then the colored image converted to grayscale .This process shown in figure (3) :

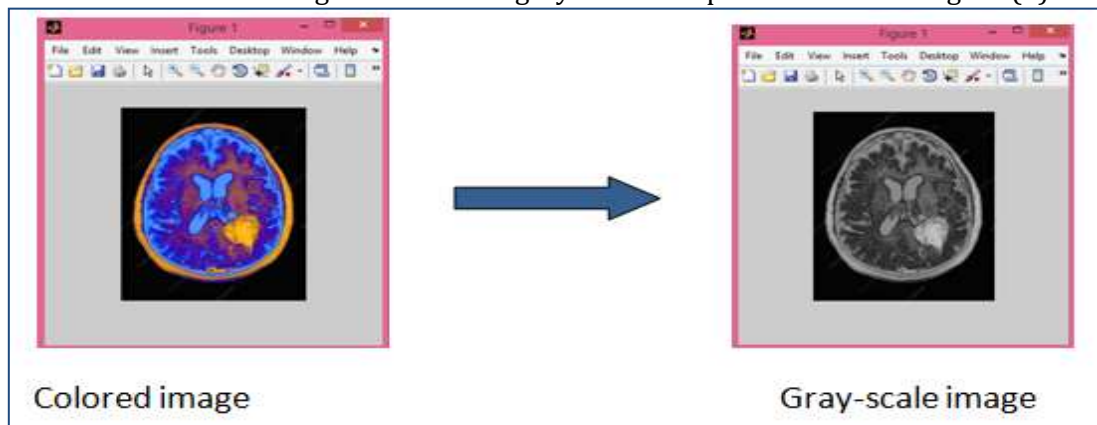


Figure 3 : Color image conversion to grayscale image

To produce a noisy image , Gaussian noise is added to grayscale image as shown in figure (4):

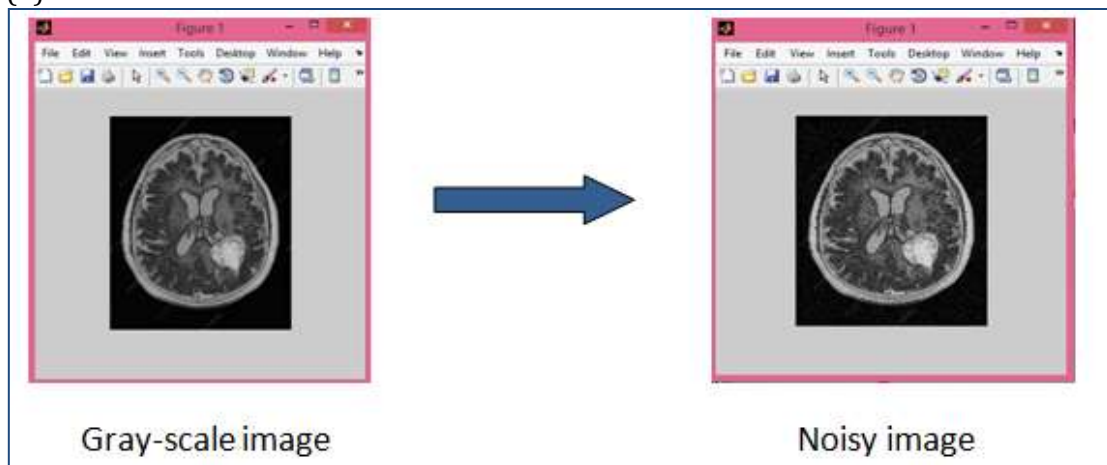


Figure 4 : Grayscale image with Gaussian noise

For enhance and removing the noise from the image an Adaptive Wiener filter is applied as shown in figure (5):

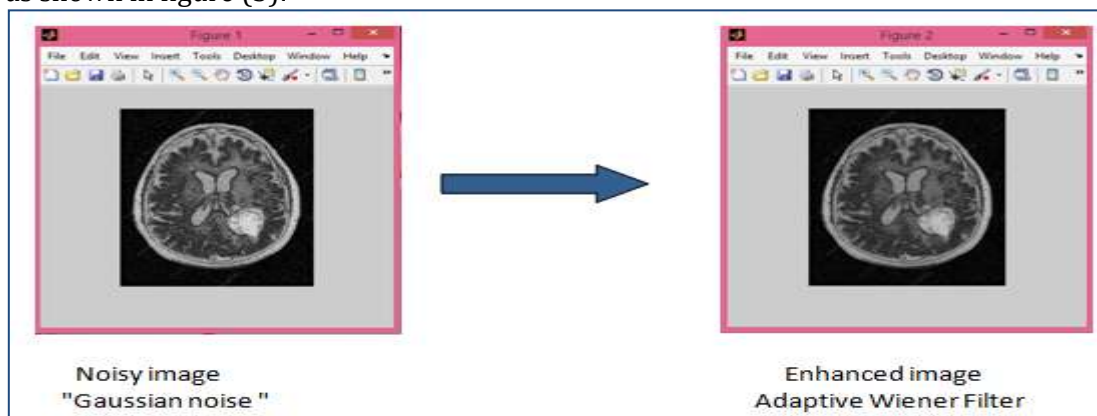


Figure 5 : The enhanced image with Adaptive Wiener filter

For the rest medical images the same steps are repeated given the results as shown in figure (6):

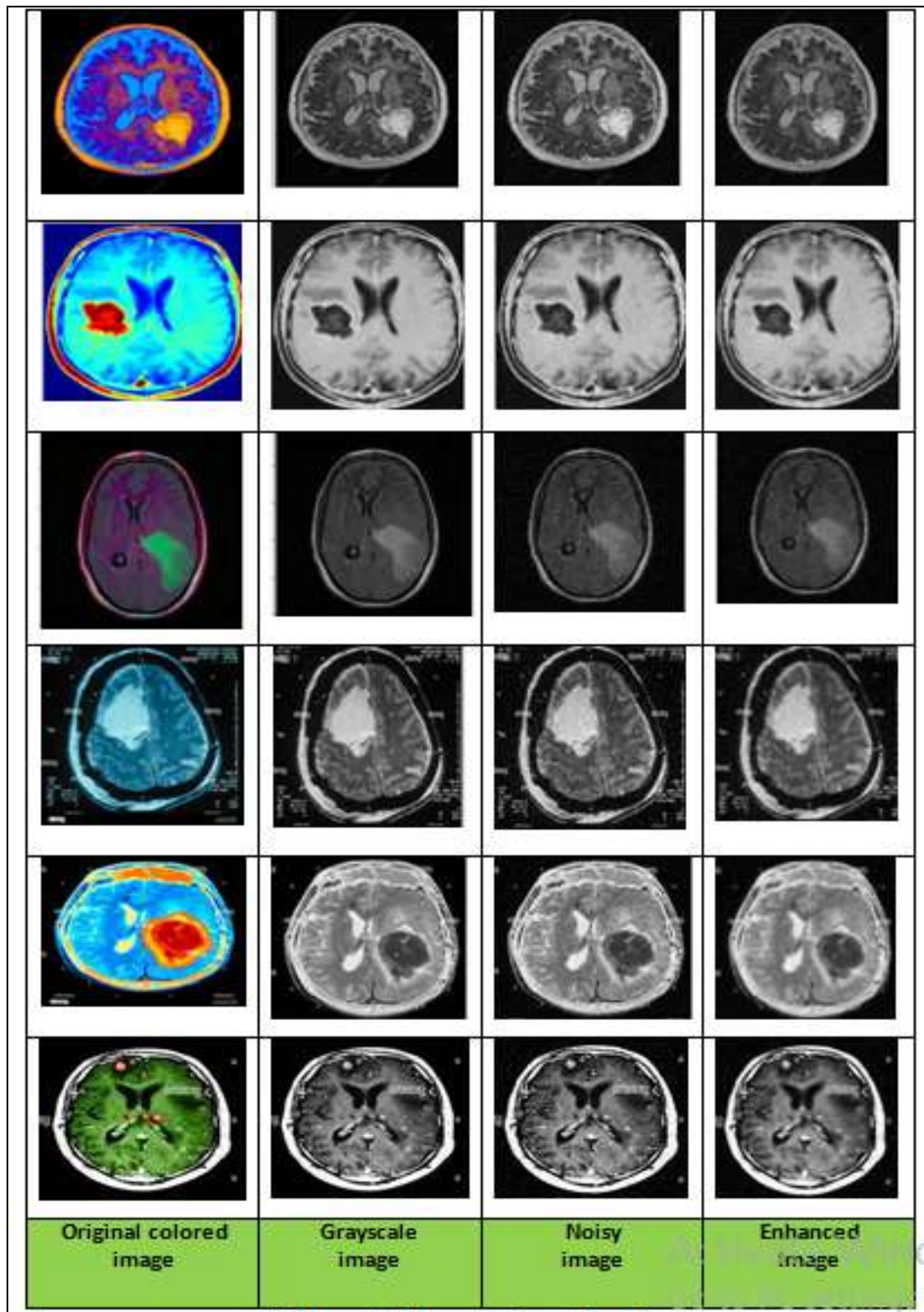


Figure 6 : The experimental results

To measure the performance level of using Adaptive Wiener filter for image enhancement compared with another filter(median)filter , the peak signal-to-noise ratio(PSNR) and mean square error (MSE) were used .The results obtained show that

the PSNR vales when using Adaptive Wiener filter are high and MSE vales are low compared with median filter . These results demonstrate high effectiveness of Adaptive Wiener filter, as shown in table(1):

Table-1- The performance criteria values for both(Adaptive Wiener Filter , Median Filter)

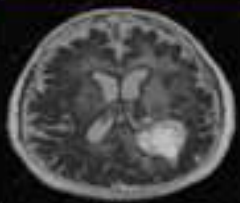
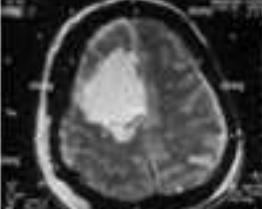
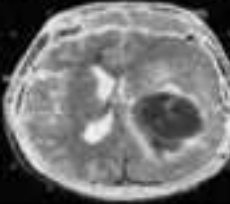
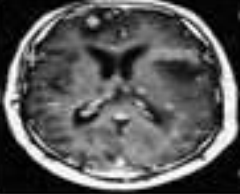
Enhanced Image	Filter type	PSNR	MSE
	Adaptive Wiener filter	29.23	78.23
	Median filter	26.92	133.08
	Adaptive Wiener filter	30.17	62.95
	Median filter	27.87	106.91
	Adaptive Wiener filter	31.70	44.27
	Median filter	30.81	54.26
	Adaptive Wiener filter	28.83	85.69
	Median filter	25.86	169.87
	Adaptive Wiener filter	27.40	119.12
	Median filter	26.05	162.66
	Adaptive Wiener filter	24.93	210.58
	Median filter	21.05	514.28

Figure (7) and figure (8) illustrate the results of PSNR, MSE for both Adaptive Wiener filter with comparison to Median Filter:

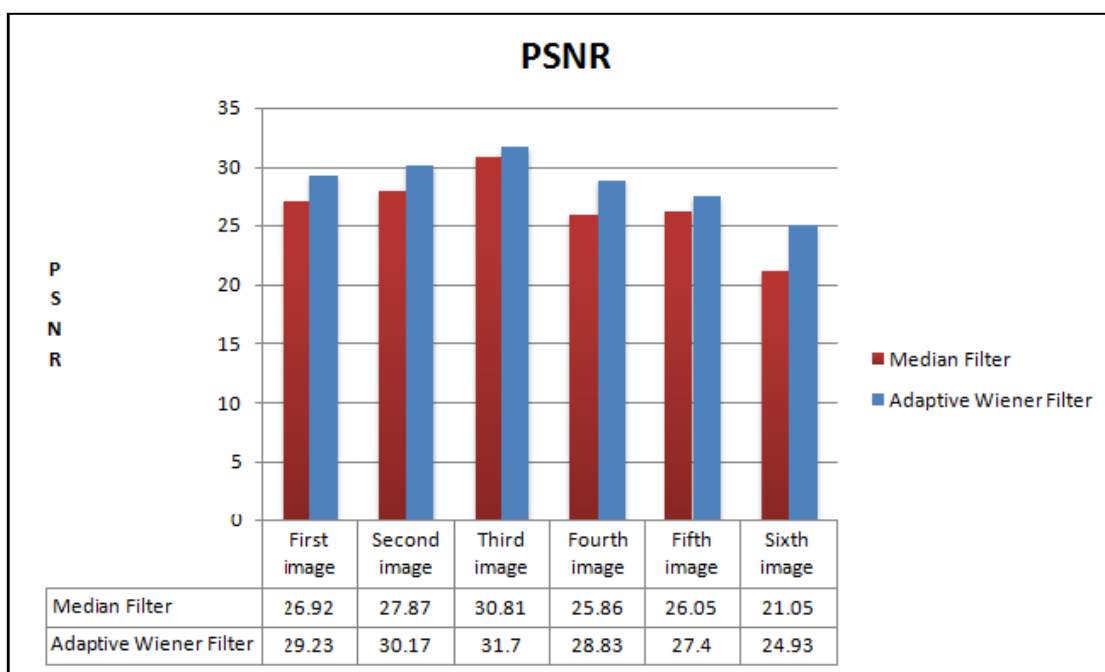


Figure 7 : PSNR values for both(Adaptive Wiener Filter , Median Filter)

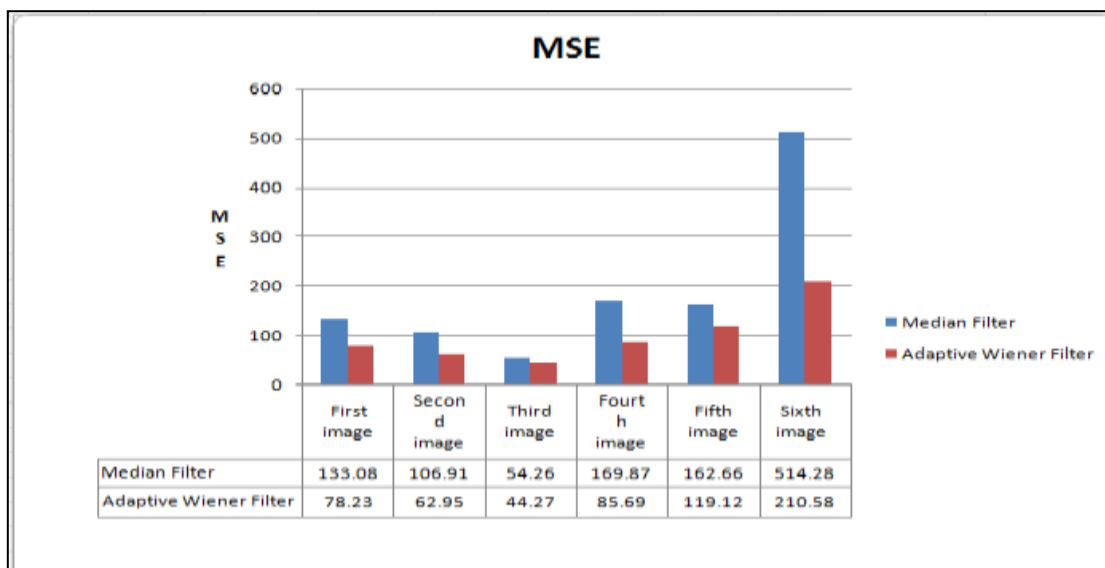


Figure 8 : MSE values for both(Adaptive Wiener Filter , Median Filter)

7. Conclusion

Medical images that taken with imaging devices are effected by noise that came from image acquisition and image transmission, this noise effect the image quality, so image enhancement methods became an important stage in image processing which helps doctors see the details and thus the diagnosis is accurate. In this paper, an effective and simple method was used to improve the quality of medical images by removing Gaussian noise present in these medical images, Here Adaptive Wiener Filter was used, this filter is characterized by a number of excellent properties that make it more selective than a similar linear filter, as it preserves edges as well as other high-frequency parts of the

image. The results obtained by comparing with another filter (Median filter) using performance criteria such as PSNR and MSE showed the efficiency of the method used.

8. References

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