# Analyzing the Application of Fourier and Wavelet Transformations for Image Noise Reduction

**Elham M. T. AbdALAmeer[1], Ashwak Alabaichi[2], Rafid Sagban[3]**

[1, 2, 3]Computer Science Dept., Kerbala University, Kerbala, Iraq

**Abstract:** ***For a proper data analysis, noise should be reduced from digital images. Effective noise reduction method is essential to increase image visual quality. Finding such kinds of methods is still going on. Fourier Transform (FT) and Wavelet Transform (WT) are potent tools for the reduction of noise from digital images. However, a few experimental researches have been conducted to conclude which of the de-noising techniques are suitable for this kind of application and when it should be used. In this paper, the intermediate and final results of noise reduction using both methods are analyzed. Experiments include using Gaussian and Periodic noises in medical images.***

**Keywords**: Gaussian Noise, Periodic Noise, De-noising, Wavelet Transform, Fourier Transform.

## 1. Introduction

Digital image processing is a computational operations use the computer algorithms to conduct image processing on digital images. It is a rapidly evolving field. Images captured are usually suffer from noise which is an undesired effect that allows false information to be added to the product of the digital image (Deserno et al., 2013). Therefore, capturing images with high accuracy can be considered as a difficult task. Examples of such noise are Salt & Pepper noise, Poisson noise, Speckle noise and Gaussian noise. Two kinds of noise are typical models of image noise they are Periodic and Gaussian noises. Periodic noise is an unwanted electrical or electromechanical interfering during acquisition process of image (Gonzalez & Woods, 2008). Gaussian noise arises during data acquisition (Kumar, Kumar, Gupta, & Nagawat, 2010).

Filtering techniques are exist to achieve a significant reduction of noise (Reis, Saraiva, & Bakshi, 2010; Tania & Rowaida, 2016). Kaur and Kaur (2012) present a comparison among several techniques to reduce all types of noises. Maity, Pattanaik, Sagnika, and Pani (2015) analyzed the methods of reducing speckle noise from biomedical images. They also provided the advantages and disadvantages of each technique in a comparative manner. Tania and Rowaida (2016) applied various filters and transformation methods to remove several kinds of noises, e.g. salt and pepper noise Gaussian noise and speckle noise exist in in aerial images. Their comparison between the said filtering and transformation methods is conducted in terms of Peak Signal to Mean Square Error (MSE) and Noise Ratio (PSNR). Attlas and Gupta (2014) analyzed three methods for removing the speckle noise from biomedical images. Abdel-Karim and Abu-Ein (2014) converted a color image to kind of gray image. 2D fast Fourier transform (denoted by 2DFFT) is applied to the converted image to improve its quality.

The objective of this paper is fourfold: to describe the types of noise that can be applied on medical image; to remove the noise of images; to apply Fourier and Wavelet transformations to de-noise the image while retaining the important signal information; and to demonstrate which method works better for each of noisy images.

## 2. Image Noise

Digital images are exposed to the noise as a result of errors in data acquisition process. This occurs due to damage in the data acquisition device, using a wrong gathering mechanism or electronic transmission of image data. The actual information of the image is modified because of the randomly variation of pixels intensity of the image. Noise is classified into Gaussian noise, uniform noise, impulse (salt-and-pepper) noise, Erlang (gamma) noise, exponential noise, photon noise, periodic noise or speckle noise.

### 2.1 Speckle Noise

Imaging sensors are prone occasionally to the affection of several environmental conditions during data acquisition. This causes a kind of noise called Speckle Noise. Such kind of noise is generated in active Radar images and medical images. This will reduce the ability of human to take the right decision through the diagnostic examinations (Attlas & Gupta, 2014). Images with speckle noise are characterised with low contrast. This situation makes it hard to do more images processing such as edge detection or segmentation. The concept of de-noising is highly required for processing high quality image via restoring it from a noisy image. Filtering is one of the de-noisy techniques to remove unwanted components or features.

### 2.2 Periodic Noise

Periodic noise causes by the intervention between two components with a fixed amplitude (Abdel-Karim & Abu-Ein, 2014). An image is corrupted by this kind of noise if the image signal is subjected to a periodic disturbance rather than a random one. Electronic interferences are the main source of the periodic noise during image acquisition in power signal.

### 2.3 Gaussian Noise

Gaussian noise is a statistical noise. Means it works based on the idea of Probability Density Function (PDF) which is similar to that of the Normal distribution. It is also known as the Gaussian distribution or electronic noise. There is a constant level of noise which is the main part of reading noise process in image sensor where the dark areas of the image. Gaussian noise in digital images arises through data acquisition. Examples of such errors are the ones caused by poor illumination, high temperature, transmission or electronic circuit noise (Boyat & Joshi, 2015). Pixels of image in Gaussian noise are changed by a small amount from its original value. Experiments showed a normal distribution of noise in the plot of the amount of distortion of a pixel value against the frequency with which it occurs. Other distributions are possible.

### 2.4 Impulse Noise

Impulse type of noise occurs high energy but short duration (Ramadan, 2014). This is happened due to bad transmission in noisy channel. It associates with large amplitude. This results infrequently in burst errors. Unlike Gaussian noise, for an impulse noise corrupted image all the image pixels are not noisy, a number of image pixels will be noisy and the rest of pixels will be noise free (Harikiran, Saichandana, & Divakar, 2010). There are different types of impulse noise namely salt and pepper type of noise and random valued impulse noise.

## 3. Noise Filtering Techniques

There are several image de-noising techniques available. Examples of such techniques are adaptive filtering techniques, median filter, wiener filters and transform based techniques. Transforming techniques such as Fourier transform, Hilbert transform and wavelet transform techniques are among the most applied filtering techniques. The following subsection presents two famous examples of transforms they are Wavelet and Fourier Transforms.

### 3.1 Wavelet Transform

Wavelet thresholding is a signal estimation strategy that endeavours the capacities of Wavelet transform for removing noise of image (see Figuere1). It evacuates noise by murdering coefficients that are insignificant in respect to some threshold. The impact of the Wavelet Transform is a convolution to gauge the similitude between an interpreted and scaled version of the Wavelet and the signal under analysis.


**Figure 1:** Wavelet thresholding in image processing

Another sort of Transform, namely Discrete Wavelet Transform (DWT), is intended to motivate the purposes of analysis and synthesis. This mechanism is characterized with accurate information, sufficient computation time, easy implementation and the ability to analyse the signal with different resolutions at different frequency bands. It separates the signal into a coarse approximation and detail information. Wavelet Transform is the optimal option to deal with the short time Fourier transforms. This is to overcome the resolution issue.

### 3.2 Fourier transform

FT is one of the important image processing techniques which is utilized to analyse an image into its basic parts, sine and cosine contents (Bracewell, 1986). It is suitable approach to discover the frequency content by providing the amount of frequencies exist in a signal. It is a reversible transform as it permits back warding and forwarding transforming of signals. Nevertheless, just both of them are available at any given time. That is, no frequency data is accessible in the time-domain signal, and no time data is accessible in the Fourier transformed signal. FT only gives the existing components of frequency in the signal. The time and frequency information cannot be seen at the same time. When the time localization of the spectral components is needed, a transform giving the Time-frequency representation of the signal is needed.

## 4. The Methodology and Results

Noise reduces the quality of any kind of images. As a result, the capability of observation of human to recognize the details of the diagnostic examination will be decrease. It is difficult to perform further image processing operations such as edge detection or segmentation. This is because of Periodic and Gaussian noise that reduces the contrast of the images. To overwhelm the problem, the methodology depicted in Figure 2 is followed. Different filtering techniques are used. In this paper the medical original image as shown in Figure 3 (a) is chosen as test image.

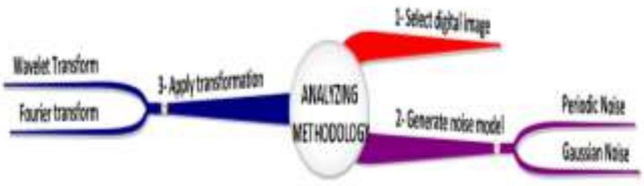


**Figure 2:** Analyzing methodology

Wavelet and Fourier Transforms are applied for de-noising purpose. Experiments are conducted using MATLAB R2016a on processor Intel Core i3-3217U with CPU @ 1.80GHz, RAM 4GB and Windows 10 64-bit operating system. Firstly, a suitable medical image is selected (see Figures 3 and 4 (a)). Secondly, noise models are generated. The selected models, i.e. Gaussian noise model and Periodic noise model, are added to the selected original medical image (Figures 3 and 4 (b)).

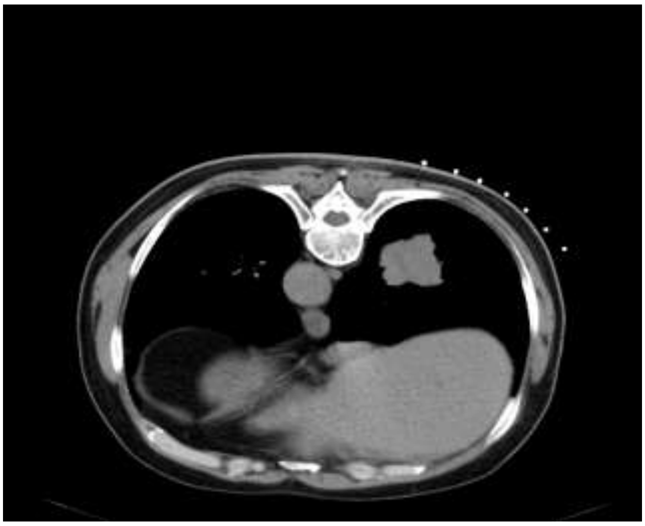

**Figure 3:** (a) Original Image (8.bmp),

**Figure 3:** (b) Noisy image result by Gaussian noise

**Figure 4:** (a) Original Image (8.bmp)

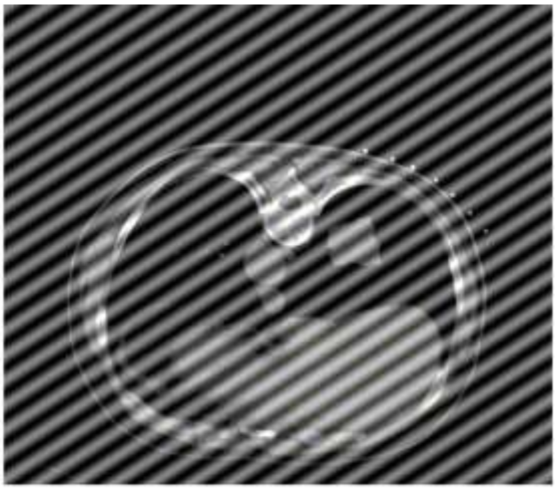

**Figure 4:** (b) Noisy image result by periodic noise

Thirdly, Wavelet and Fourier transforms are used to de-noise Gaussian and Periodic noising model respectively. For Wavelet transform, de-noising functions namely *Gaussian_driver* and *Gaussdenoise*lead. The two functions are necessary to implement de-noising process on Gaussian noisy image. The first input of the former function (*Gaussian_driver*) is *Filename* which is the file name of the file of noisy image. The second input namely "*Ext"*. It is the extension of the file of noisy image. The third input "*View"* is to display the final result. Finally the "*Write"* input is to display final result. To conduct the flow work the image from file is read. The image should be converted to greyscale. Results of different type of Gaussian de-noising is presented and displayed.

The later function namely *Gaussdenoise* includes two inputs they are *Image* and output. The first input uses to input the noisy image, *N* to indicate to the wavelet number processes to remove noisy of image and the second input uses to produce the filtered image. Converting image to a matrix of double is the results of several steps. These are:

i) apply the previous function;
ii) initialize parameters of de-noising process of wavelet;
iii) compute the output of the de-noising process; and
iv) display last result of image.

Results of de-noising image are depicted as in Figure 5 (a) and (b).

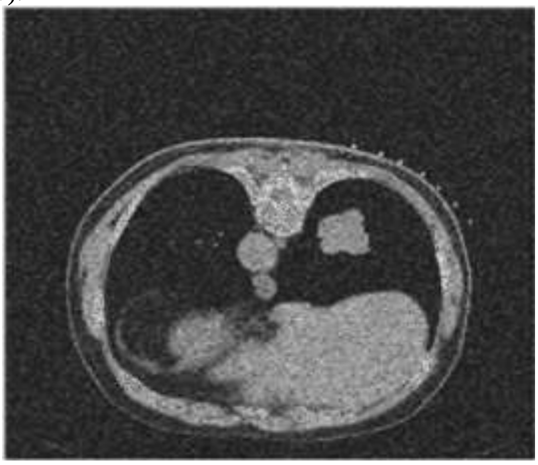

**Figure 5:** (a) De-noising process with N=2,

**Figure 5:** (b) De-nois ing process with N=6

For Fourier transform, de-noising functions namely *Periodic_driver*, *Circlefilter* and *viewfft* lead the process of implementing de-noising filter on Periodic noisy image. The specifications of the first function (*Periodic_driver*) are read image from the file; convert image to greyscale, create image of FT spectrum, define parameters of de-noising, implement circle filters kinds of FT spectrum and compute Fourier transform, compute reverse FT of the enhanced spectrum and write de-noised image. It determines the path of noisy image (e.g. *periodic_ driver ('periodic',' bmp', true, true)*) before the function 'periodic_ driver' is called. The second function is normally defines a filter namely *circlefilter* to give the FT spectrum (see Figure 6 (a)). The goal of the function is reducing the impact of periodic noise. It can be done by input FT spectrum and generate a new FT spectrum to reduce effect of periodic noise (see Figure 6 (b)). The third function namely *viewfft* has simple effect on the given FT spectrum (see Figure (c)). The result images of applying the three functions this function are shown in Figure 6 (a-c).

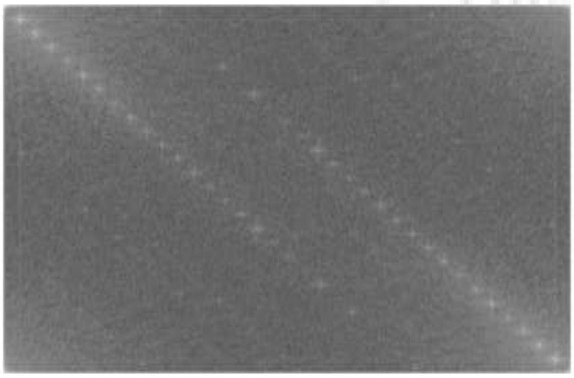

**Figure 6:** (a) FT spectrum of the image,

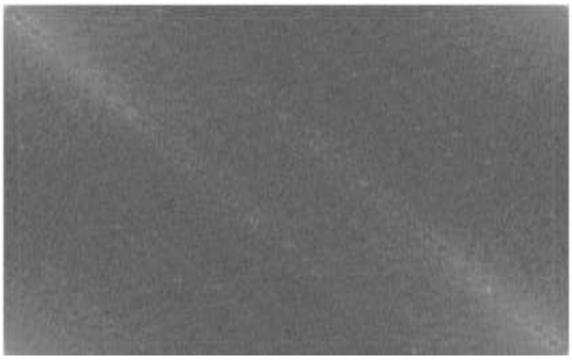

**Figure 6:** (b) FT spectrum of the image,

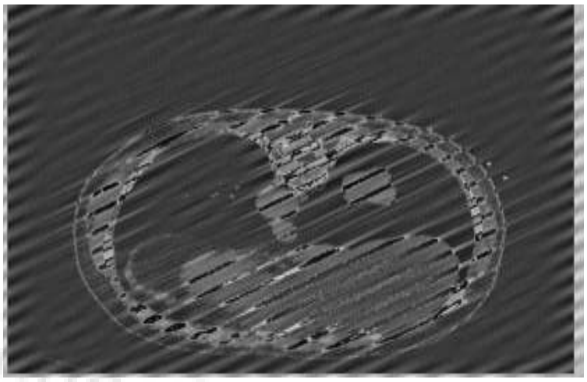

**Figure 6:** (c) Last de- noised image

## 5. Work steps for remove noise from image

### 5.1 Remove noisy by using 'wavelet de-noising':

**1) Gaussian _drive: The work steps of this function are:**
a) Reading the image from file.
b) Converting image to greyscale.
c) Computing results of different type of Gaussian
d) de-noising.
e) Display results.
f) Writing results to disc.

**2) Gaussdenoise: The work steps of this function are:**
a) Converting image to a matrix of double.
b) Computing initial parameters of wavelet de-
c) Noising process.
d) Computing the output of the de-noising process.
e) Compute last result of image.

### 5.2 Remove noise from Periodic images by using FFT Denoising:

a) Reading image from the file.
b) Converting image to greyscale.
c) Creates FFT spectrum of the image.
d) Defining of de-noising parameters.
e) Implementing circle filters on the FFT spectrum and computing FFT.
f) Computing reverse FFT of the enhanced Spectrum.
g) Writing result de-noised image.

## 6. Conclusion

Returning the information of medical image is not available with existence of noise. This will reduce the ability of human to take the right decision through the diagnostic examinations. Fourier and Wavelet Transforms are the most applied de-noising techniques in the field of image processing to reduce the noise. This paper followed the experimental approach to conclude which of the said de-noising techniques are better. Fourier domain filtering for periodic noise reduction is considered as a simple but effective method in imaging processing. It is an efficient methodology to remove periodic noise from digital images. It makes the image texture and edges remained untouched. The contrast to noise ratio (CNR) of processed images increased admittedly. It is a low cost effective post processing method for periodic noise reduction. It is clear that the FT method is suitable for removing the periodic noisy images. Additional signal added to image is easily removed it from image. On the other side, as Gaussian noise is generated from a random source it cannot be discovered. Therefore methods of FT are not successful with Gaussian noise. Thus, wavelet de-noising methods are suitable to Gaussian noisy images.

## References

[1] Abdel-Karim, A., & Abu-Ein, H. (2014). A novel methodology for digital removal of periodic noise using 2D fast Fourier transforms. Contemporary Engineering Sciences, 7(3), 103–116. http://doi.org/10.12988/ces.2014.31065

[2] Attlas, N., & Gupta, S. (2014). Reduction of Speckle Noise in Ultrasound Images using Various Filtering techniques and Discrete Wavelet Transform : Comparative Analysis Wavelet Transform : Comparative Analysis. International Journal of Research (IJR), 1(6), 112–117.

[3] Boyat, A. K., & Joshi, B. K. (2015). A Review Paper : Noise Models in Digital Image Processing. Signal & Image Processing : An International Journal, 6(2), 63–75. http://doi.org/10.5121/sipij.2015.6206

[4] Bracewell, R. N. (1986). The Fourier Transform and its Applications. Transform (Vol. 42). http://doi.org/10.1049/ep.1965.0268

[5] Deserno, T. M., Handels, H., Maier-Hein, K. H., Mersmann, S., Palm, C., Tolxdorff, T., … Wittenberg, T. (2013). Viewpoints on Medical Image Processing: From Science to Application. Current Medical Imaging Reviews, 9(2), 79–88. http://doi.org/10.2174/1573405611309020002

[6] Gonzalez, R. C. ., & Woods, R. E. (2008). Digital image processing. Nueva Jersey. http://doi.org/10.1049/ep.1978.0474

[7] Harikiran, J., Saichandana, B., & Divakar, B. (2010). Impulse Noise Removal in Digital Images. International Journal of Computer Applications, 10(8), 39–42. http://doi.org/10.5120/1498-2015

[8] Kaur, G., & Kaur, R. (2012). Image De-Noising using Wavelet Transform and Various Filters. International Journal of Research in Computer Science, 2(2), 15–21. http://doi.org/10.7815/ijorcs.22.2012.017

[9] Kumar, S., Kumar, P., Gupta, M., & Nagawat, A. K. (2010). Performance Comparison of Median and Wiener Filter in Image De-noising. International Journal of Computer Applications, 12(4), 27–31. http://doi.org/10.5120/1664-2241

[10] Maity, A., Pattanaik, A., Sagnika, S., & Pani, S. (2015). A Comparative Study on Approaches to Speckle Noise Reduction in Images. 2015 International Conference on Computational Intelligence and Networks, (JANUARY), 148–155. http://doi.org/10.1109/CINE.2015.36

[11] Ramadan, Z. M. (2014). Salt-and-Pepper Noise Removal and Detail Preservation Using Convolution Kernels and Pixel Neighborhood. American Journal of Signal Processing, 4(1), 16–23. http://doi.org/10.5923/j.ajsp.20140401.03

[12] Reis, M. S., Saraiva, P. M., & Bakshi, B. R. (2010). Denoising and Signal-to-Noise Ratio Enhancement: Wavelet Transform and Fourier Transform. In Comprehensive Chemometrics (Vol. 2, pp. 25–55). http://doi.org/10.1016/B978-044452701-1.00099-5

[13] Tania, S., & Rowaida, R. (2016). A Comparative Study of Various Image Filtering Techniques for Removing Various Noisy Pixels in Aerial Image. International Journal of Signal Processing Image Processing and Pattern Recognition, 9(3), 113–124. http://doi.org/10.14257/ijsip.2016.9.3.10

## Author Profile

**Elham M. T. AbdALAmeer** awarded her B.Sc at Al-Mustansiriya University in Iraq, College of Science, Department of Computer Science in 1994, and M.Sc, at Kingston University London in UK, Faculty of Computing, Information Systems and Mathematics in 2010 respectively. She is a lecturer at Department of Computer Science, College of Science, Karbala University, Karbala, Iraq. Here research interests include: Information Systems, System Analysis , Database, and E- business.

**Ashwak ALabaichi,** Bachelor in Computer Science, Babylon University, Iraq, Higher Diploma in security, Iraqi Commission for Computer & Informatics, Informatics Institute for Postgraduate Studies, Baghdad, Iraq, 2002,M.Sc. in Security/ Steganalysis, Iraqi Commission for Computer & Informatics, Informatics Institute for Postgraduate studies, Baghdad, Iraq, 2005, Lecturer at Kerbalaa University. Ph.D. in cryptography, University Utara Malaysia. Published more 16 articles