وزارة التعليم العالي والبحث العلمي
جامعة ديالى / كلية التربية الأساسية
قسم الحاسبات

Image de-noising by using various filters

بحث مقدم إلى مجلس كلية التربية الأساسية - قسم الحاسبات وهو جزء من متطلبات نيل شهادة البكالوريوس في الحاسبات

من قبل الطالبة
هناء طاهر حسين

باشراف الأستاذة

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١٤٣٩هـ ٢٠١٨م

بِسْمِ اللهِ الرَّحْمنِ الرَّحِيْمِ

((خَلَقَ السَّمَاوَاتِ وَالْأَرْضَ بِالْحَقِّ وَصَوَّرَكُمْ فَأَحْسَنَ صُوَرَكُمْ وَإِلَيْهِ الْمَصِيرُ))

صدق الله العظيم

(سورة التغابن: الآية ٣)

الاهداء

. . .الى امتنا العربية الاسلامية المجيدة . . .

الى من كان سببا في وجودنا وسهر الليالي الطوال من اجلنا والدينا

اعزهم الله في الدنيا ورحمهم في الاخرة . . . .

. .الى اساتذة ومؤسسي كلية التربية الاساسية .

. . .الى اساتذتنا الاعزاء الاجلاء . . .

. . .الى الذين رسموا لنا طريق العلم وكانوا سببا في تعليمنا وتأديبنا وتهذيبنا .

. . .الى اساتذتي وعائلتي وزملائي وكل من ساندني في اتمام

بحثي اهدي اليهم ثمرة جهدي هذا المتواضع . .

الباحثة

شكر وتقدير

الحمد لله حمداً يليق بكماله واستعين به استعانة تليق بجلال ربوبيته، اشكره واثني عليه لإنجاز هذا البحث واصلي على اصدق معلم واشرف من حمل لرسالة العلم والتعليم ابي القاسم (محمد) ﷺ.

وقد شارف هذا الجهد على ختامه ان اتقدم بجميل احترام وتقديري لأستاذتي الفاضلة (زينب محمد قحطان) المشرفة على هذا البحث ، لما قدّمته من رعاية علمية وتوجيهات سديدة فقد كانت لتوجيهاتها وإرشاداتها أكيد الاثر في أنجازه فجزاها الله خير الجزاء .

وأتقدم بالشكر والتقدير إلى رئاسة قسم الحاسبات وإلى جميع أساتذتي الأفاضل في قسم الحاسبات وجزيل شكري وخالص تقديري إلى والدي العزيزين اطال الله في عمرهما وإلى إخواني وأخواتي الذين كانوا خير عون ومساعدة.

المحتويات

CHAPTER ONE

1-1 Abstract

Image de-noising is very important during enhancement of image. Original Image is generally corrupted with various types of noise. The noise present in the images may appear as additive or multiplicative components. The most challenging problem is removing that noise from an Image while preserving its details. Several noise removal techniques have been developed so far each having its own advantages and disadvantages. The focus of this paper is to study various spatial filters and to compare their performance in removing different types of noise. So four types of noise(Gaussian noise ,sal t& pepper noise speckle noise , poisson noise) is used and image de-noising done for all different noise by (mean filter , median filter ,wiener filter) Here quantitative measure of comparison is provided by mean square error(MSE) and the Peak Signal to Noise Ratio (PSNR) parameter. This project include five chapters:- in chapter one we have (abstract ,introduction and previous study ,in chapter two we will speak about principles of image processing , in chapter three we have image enhancement , in chapter four we will show the results

after de-noising the image by the three filters and the conclusion will be included in chapter five.

Introduction : Image de-noising is an vital image processing task i.e. as a process itself as well as a component in other processes. There are many ways to de-noise an image or a set of data and methods exists. The important property of a good image de-noising model is that it should completely remove noise as far as possible as well as preserve details . Noise removing from an image is an important task in different applications such as medical which the noise free images could leads to less error detection. Filtering as a tool for noise removal is concerned in this paper. The purpose is to compare the performance of three filters - Median Filter, Mean Filter and Wiener filter- for de-noising from Gaussian noise, Salt & Pepper noise, Poisson noise and Speckle noise.

1-2 Introduction

As result of the great progress that has recently taken place in various fields, everyone has noticed the strong in tersest in the programs related to the image and its clarity. Therefore attention to the principles of image processing and improvement of the image in necessary to deal with the images before using in many fields such as medical .Traffic and identification of the identities of the people so it was chosen from this area of research to find improved the images affected by poor distribution of lighting.

1-3 Problem Statement

With growing application in science and engineering digital image processing is treated as a rapidly evolving field. In the real world signals do not exist without noise, which arises during image acquisition (digitization) and/or transmission. When images are acquired using a camera, light levels and sensor temperature are major factors affecting the amount of noise. During transmission, images are corrupted mainly due to interference in the channel used for transmission. Removing noise from images is an important problem in image processing In the early development of image processing, linear filters were the primary tools for image enhancement and restoration

.

1-4 Importance of research

Image de-noising is one of the important and essential components of image processing. Many scientific data sets picked by the sensors are normally contaminated. By noise it is contaminated either due to the data acquisition process. Or due to naturally occurring phenomenon [u].

There are several special cases of distortion, one of the most prevalent cases is due to the additive white Gaussian noise caused by poor image acquisition or by communicating the image data through noisy channels. Other categories include impulse and speckle noises. The goal of de noising algorithm is to remove the un wanted noise while preserving the important signal features as much as possible. Noise elimination introduce artifacts and blur in the images. So image de noising is still a challenging task for the investigators. Several methods are being developed to perform de noising of corrupted images [5].

1-5 Research goal

The goal of image filtering is to remove the unwanted noise while preserving the important signal features as much as possible. Noise elimination introduce artifacts and blur in the images. So image de noising is still a challenging task for the investigators developed to perform de noising of corrupted image [5].

1-6 Previous study

1- Comparing the Performance of Various Filters on Skin Cancer Images Azadeh Noori Hoshyar a,*, Adel Al-Jumailya , Afsaneh Noori Hoshyar.

Abstract :- Noise removing from an image is an important task in different applications such as medical which the noise free images could leads to less error detection. Filtering as a tool for noise removal is concerned in this paper. The purpose is to compare the performance of five filters - Median Filter, Adaptive Median Filter, Mean Filter, Gaussian Filter and Adaptive Wiener filter- for de-noising from Gaussian noise, Salt & Pepper noise, Poisson noise and Speckle noise.

2- Image De-noising by Various Filters for Different Noise using MATLAB

Submitted By-Jitesh Gupta(54/EC/10) Karan
- Choudhary(56/EC/10) Kovil Singh(57/EC/10)

ABSTRACT :- Image processing is basically the use of computer algorithms to perform image processing on digital images.

Digital image processing is a part of digital signal processing. Digital image processing has many significant advantages over analog image processing. Image processing allows a much wider range of algorithms to be applied to the input data and can avoid problems such as the build-up of noise and signal distortion during processing of images. Wavelet transforms have become a very powerful tool for de-noising an image. One of the most popular methods is wiener filter. In this report four types of noise (Gaussian noise , Salt & Pepper noise, Speckle noise and Poisson noise) is used and image de-noising performed for different noise by Mean filter, Median filter and Wiener filter . Further results have been compared for all noises.

3- Interpret Singh M. Tech Student Department of Computer Engineering Punjabi University, Patiala, Nervier Nero Assistant Professor Department of Computer Engineering Punjab University, Patiala, International Journal of Computer Applications (0975 – 8887) Volume 96-No.19, June 2014(Performance Comparison of Various Image DE noising Filters Under Spatial Domain).

Abstract :- Image de-noising is very important during enhancement of image. Original Image is generally corrupted with various types of noise. The noise present in the images may appear as additive or multiplicative components. The most challenging problem is removing that noise from an Image while preserving its details. Several noise removal techniques have been developed so far each having its own advantages and disadvantages. The focus of this paper is to study various spatial filters and to compare their performance in removing different types of noise. Here quantitative measure of comparison is provided by the Peak Signal to Noise Ratio (PSNR) parameter.

CHAPTER TWO

Introduction to image Processing

2-1 what are images?

In the broadest possible sense, images are pictures: away of recording and presenting information visually. Pictures are important to us because they can be an extraordinarily effective medium for the storage and communication of information. In showing someone a photograph, we avoid the need for lengthily, tedious, and in all likelihood, ambiguous verbal description of what was seen .

There is thus a scientific basis for the well- known saying that '' picture is worth a thousand words ''

Definition: An image is a representations, likeness, or imitation of an object or thing, a vivid or description, something introduced to represent something else.

An image is usually a condensation or summary of the information in the object it represent. Ordinarily, an image contains less information than the original object. Therefore, an image is an incomplete, yet, in some sense adequate, representation of the Object.

2-2 Digital Images

An image must be converted to numerical from before processing. This conversion process is called digitization The image is divided into small regions calledpicture elements, or pixel for short. The must common subdivision scheme is the rectangular sampling grid. The image is divided into horizontal lines made up of adgacent pixels. At each pixel location, the image brightness is sampled and quantized. This step generates an integer at each pixel representing the brightness or darkness of the image at that point. When this has been done for all pixels, the image is represented by a rectangular array of integer. Each pixel has a location or address (Line or row number and sample or column number) and an integer value called gray level. This array of digital date is now a candidate for computer processing.

2-3 Image Processing

Image Processing is computer imaging where application involves a human being in the visual loop. In other words the image are to be examined and a acted upon by people. The major topics within the field of image processing include:

2-3-1 Image Acquisition

2-3-2 Image restoration.

2-3-3 Image enhancement.

2-3-4 Image compression.

2-3-1 Image Acquisition

Image Acquisition In this step, the image is captured by a sensor (such as a monochrome or color TV camera) and digitized, if the output of the camera or sensor is not already in digital form- an analog-to-digital converter (ADC) digitizes it.

2-3-2 Image Restoration

Is the process of taking an image with some known, or estimated degradation, and restoring it to its original appearance. Image restoration is often used in the field of photography or publishing where an image was somehow degraded but needs to be improved before it can be printed.

2-3-3 Image Enhancement

Involves taking an image and improving it visually, typically by taking advantages of human Visual Systems responses, One of the simplest enhancement techniques is to simply stretch the contrast of an image. Enhancement methods tend to be problem specific. For example, a method that is used to enhance satellite images may not suitable for enhancing medical images. Although enhancement and restoration are similar in aim, to make an image look better, they differ in how they approach the problem, Restoration method attempt to model the distortion to the image and reverse the degradation, where enhancement methods use knowledge of the human visual systems responses to improve an image visually.

2-3-4 Image compression

Involves reducing the typically massive amount of data needed to represent an image, This done by eliminating data that are visually unnecessary and by taking advantage of the redundancy that is inherent in most images. Image processing systems are used in many and various types of environments, such as:

1-Medical community

2-Computer – Aided Design

3-Virtual Reality

Components of Image Processing System

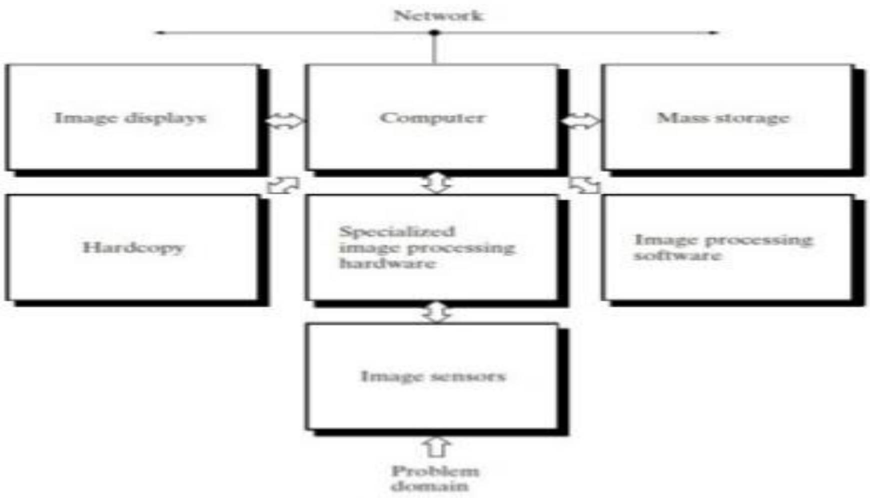


Figure (1) Image Processing System

2-4 Digital Image Representation:

An image defined in the ''real world'' is considered to be a function of two real variables, for example, f(x,y) with f as the amplitude (e.g. brightness) of the image at the real coordinate position (x,y). When we have the data in digital form, we can use the software to process the data". The digital image is 2D-array as:

I(0,0)   I(0,1)…………………………….I(0,N-1)

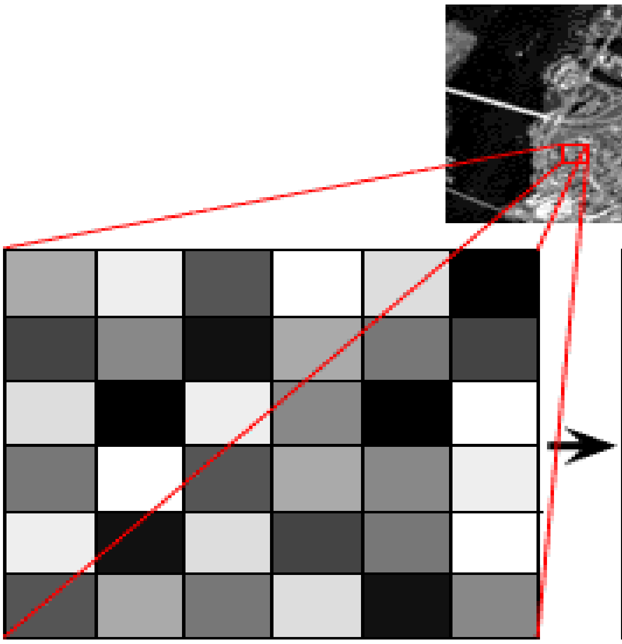
I(1,0)   I(1,1)…………………………….I(1,N-1)

……………………………………………………….

……………………………………………………….

I(N-1,0)   I(N-1,1)………………….I(N-1,N-I)

The effect of digitization is shown in Figure 4.



170	238	85	255	221	0
68	136	17	170	119	68
221	0	238	136	0	255
119	255	85	170	136	238
238	17	221	68	119	255
85	170	119	221	17	136

Figure 4 digitization of image

The 2D continuous image f(x,y) is divided into N rows and M columns. The intersection of a row and a column is called as pixel. The value assigned to the integer coordinates [m,n] with {m=0,1, 2,….,M-1} and {n=0,1,2,…,N-1} is f[m,n]. In fact, in most cases f(x,y)—which we might consider to be the physical signal that impinges on the face of a sensor. Typically an image file such as BMP, JPEG, TIFF etc., has some header and picture information. A header usually includes details like format identifier (typically first information), resolution, number of bits/pixel, compression type, etc.

2-5 Sampling

The process of creating a digital image from date acquired by a camera or some other kind of imaging instrument required a two-dimensional pattern to represent the measurements (light intensity or co lour), that are made in the form of an image numerically.

We can describe the pattern by a function f ((x,y)). For monochrome image, the value of the function at any pair of coordinates, x and y is the intensity of the light detected at that point. In the case of co lour images f ((x,y)) is a vectored-value function the function f ((x,y)) must be translated into a discrete array of numerical date if it is to undergo computer processing. Translation of a f ((x,y)) into an appropriate numerical form is accomplished by the process of sampling and quantization.

Sampling: is a process of measuring the value of the image function f ((x,y)) at discrete intervals in space. Each sample corresponds to a small square area of the image, known as a pixel. A digital image is a two-dimensional array of these pixels. Pixels are indexed by x and y coordinates, with x and y taking integer values.

2-6 Quantization

An image must be converted to numerical from before processing. This conversion process is called digitization, and a common from is illustrated in figure 3.The image is divided into small regions called picture elements, or pixel for short. The must common subdivision scheme is the rectangular sampling grid shown in figure 3. The image is divided into horizontal lines made up of adjacent pixels. At each pixel location, the image brightness is sampled and quantized. This step generates an integer at each pixel representing the brightness or darkness of the image at that point. When this has been done for all pixels, the image is represented by a rectangular array of integer. Each pixel has a location or address (Line or row number and sample or column number) and an integer value called gray level.

This array of digital date is now a candidate for computer processing.

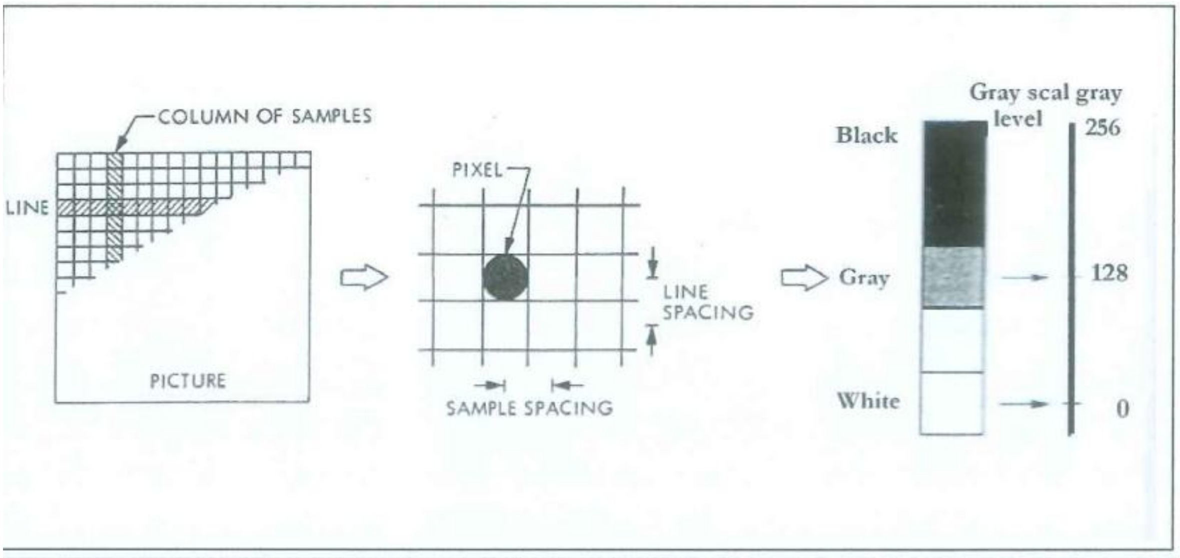


Figure 3 Digitizing an Image

CHAPTER THREE

IMAGE ENHANCEMENTS

3-1 Introduction

Image Enhancement techniques are used to emphasize and sharpen image features for display and analysis. Image enhancement is the process of applying these techniques to facilitate the development of a solution to a computer imaging problem. Consequently, the enhancement methods are application specific and are often developed empirically. Figure 8 illustrates the importance of the application by the feedback loop from the output image back to the start of the enhancement process and models the experimental nature of the development. In this figure we define the enhanced image as E(r,c). The range of applications includes using enhancement techniques as preprocessing steps to ease the next processing step or as postprocessing steps to improve the visual.

Spatial domain processing methods include all three types, but frequency domain operations, by nature of the frequency (and sequency) transforms, are global operations Of course, frequency domain operations can become "mask operations," based only on a local neighborhood, by performing the transform on small image blocks instead of the entire image.

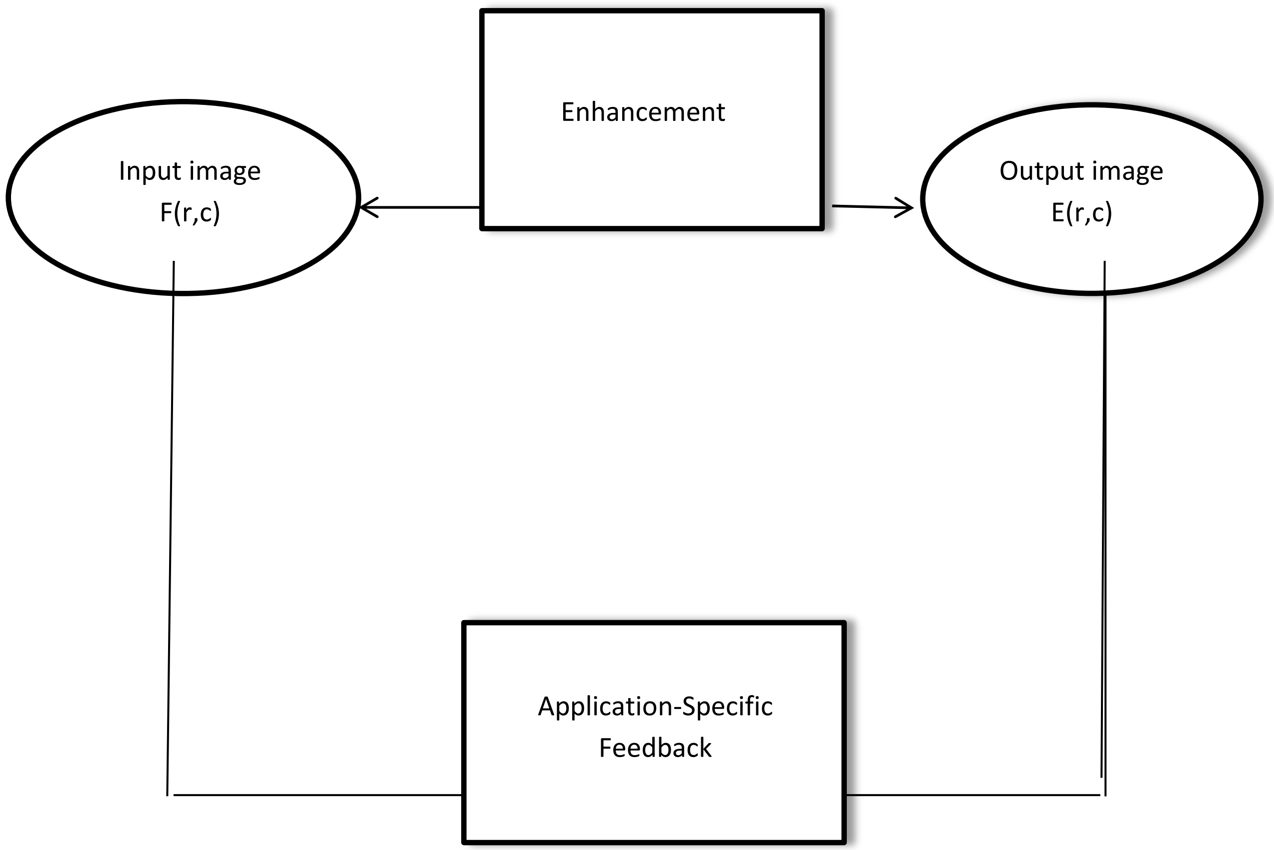


Figure (8) The image Enhancement Process

Enhancement is used as a preprocessing step in some computer vision applications to ease the vision task, for example, to enhance the edges of an object to facilitate guidance of a robotic gripper. Enhancement is also used as a preprocessing step in applications where human viewing of an image is required before further processing. For example, in one application, high-speed film images had to be correlated with a computer-simulated model of an aircraft.

Overall, image enhancement methods are used to make images look better. What works for one application may not be suitable for another application, so the development of enhancement methods require problem domain knowledge, as well as image enhancement expertise. Assessment of the success of an image enhancement algorithm is often "in the eye of the beholder," so image enhancement is as much an art as it is a science. Figure 9:

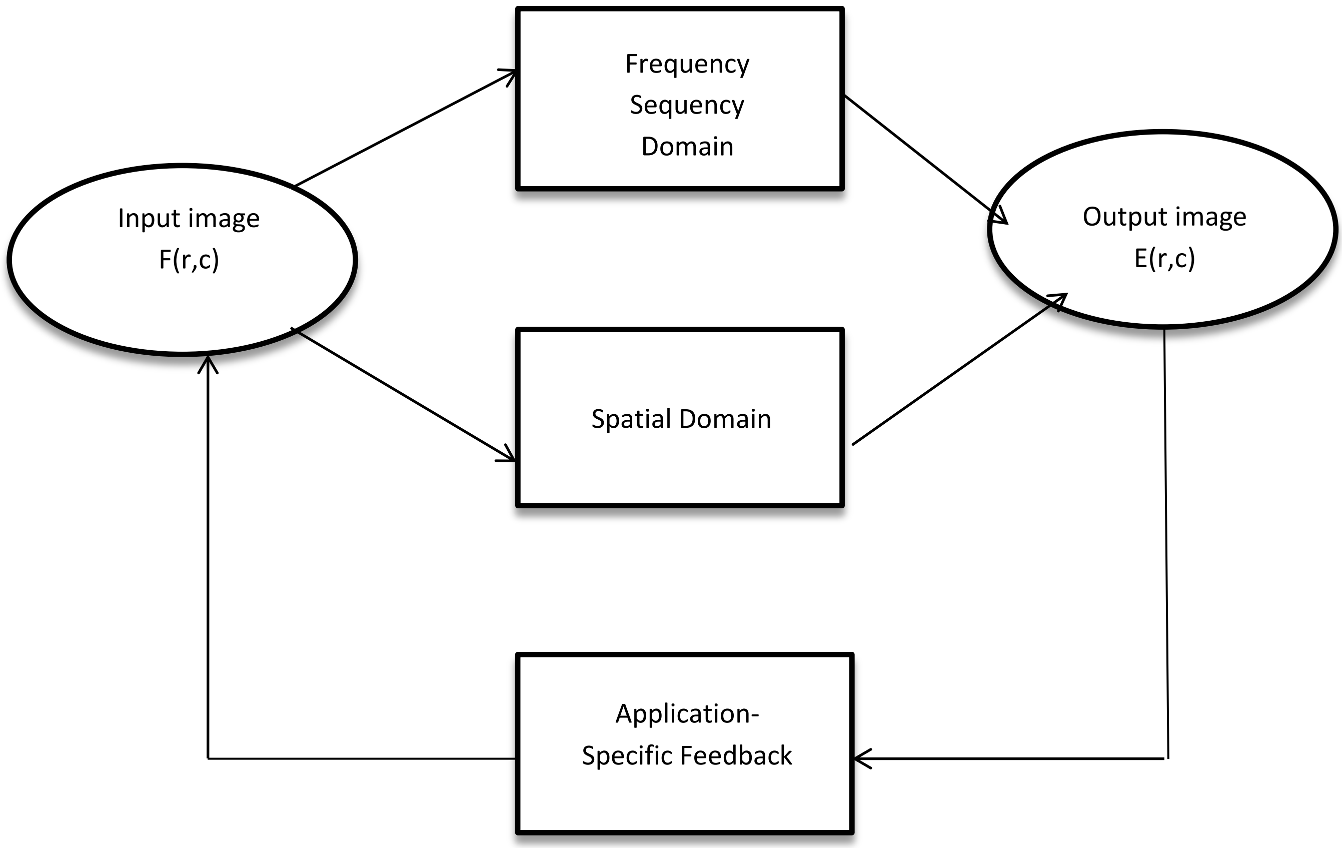


Figure 9 Image Enhancement

.

3-2 Image Noise

Image noise is the random variation of brightness or color information in images produced by the sensor and circuitry of a scanner or digital camera. Image noise can also originate in film grain and in the unavoidable shot noise of an ideal photon detector [4].Image noise is generally regarded as an undesirable by-product of image capture. Although these unwanted fluctuations became known as "noise" by analogy with unwanted sound they are inaudible and such as dithering. The types of Noise are following:-

3-2-1 Amplifier noise (Gaussian noise)

3-2-2 Salt-and-pepper noise

3-2-3 Shot noise(Poisson noise)

3-2-4 Speckle noise.

3-2-1 Amplifier noise (Gaussian noise)

The standard model of amplifier noise is additive, Gaussian, independent at each pixel and independent of the signal intensity. In color cameras where more amplification is used in the blue color channel than in the green or red channel, there can be more noise in the blue channel .Amplifier noise is a major part of the "read noise" of an image sensor, that is, of the constant noise level in dark areas of the image [4] .

3-2-2 Salt-and-pepper noise

An image containing salt-and-pepper noise will have dark pixels in bright regions and bright pixels in dark regions [4]. This type of noise can be caused by dead pixels, analog-to-digital converter errors, bit errors in transmission, etc. This can be eliminated in large part by using dark frame subtraction and by interpolating around dark/bright pixels.

3-2-3 Poisson noise

Poisson noise or shot noise is a type of electronic noise that occurs when the finite number of particles that carry energy, such as electrons in an electronic circuit or photons in an optical device, is small enough to give rise to detectable statistical fluctuations in a measurement [4].

3-2-4 Speckle noise.

Speckle noise is a granular noise that inherently exists in and degrades the quality of the active radar and synthetic aperture radar (SAR) images. Speckle noise in conventional radar results from random fluctuations in the return signal from an object that is no bigger than a single image-processing element. It increases the mean grey level of a local area. Speckle noise in SAR is generally more serious, causing difficulties for image interpretation. It is caused by coherent processing of backscattered signals from multiple distributed targets. In SAR oceanography [5]

,for example, speckle noise is caused by signals from elementary scatters, the gravity-capillary ripples, and manifests as a pedestal image, beneath the image of the sea.

3-3 NOISE FILTERING

3-3-1 Removing Noise By Linear Filtering.

We can use linear filtering to remove certain types of noise. Certain filters, such as averaging or Gaussian filters, are appropriate for this purpose. For example, an averaging filter is useful for removing grain noise from a photograph. Because each pixel gets set to the average of the pixels in its neighborhood, local variations caused by grain are reduced. Conventionally linear filtering Algorithms were applied for image processing. The fundamental and the simplest of these algorithms is the Mean Filter .The Mean Filter is a linear filter which uses a mask over each pixel in the signal. Each of the components of the pixels which fall under the mask are averaged together to form a single pixel. This filter is also called as average filter. The Mean Filter is poor in edge preserving. The Mean Filter can be defined as-

Mean filter (x1…..xN) = – Σ xi/N

where (x1 ….. xN) is the image pixel range. Generally linear filters are used for noise suppression.

The idea of mean filtering is simply to replace each pixel value in an image with the mean (`average') value of its neighbors, including itself. This has the effect of eliminating pixel values which are unrepresentative of their surroundings. Mean filtering is usually thought of as a **convolution filter**. Like other convolutions it is based around a **kernel**, which represents the shape and size of the neighborhood to be sampled when calculating the mean. Often a 3×3 square kernel is used, as shown in Figure 1, although larger kernels (e.g. 5×5 squares) can be used for more severe smoothing. (Note that a small kernel can be applied more than once in order to produce a similar but not identical effect as a single pass with a large kernel.)

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

3x3 averaging kernel often used in mean filtering

Computing the straightforward convolution of an image with this kernel carries out the mean filtering process.

3-3-2 Removing Noise By Median Filtering

The Median filter is a nonlinear digital filtering technique, often used to remove noise. Such noise reduction is a typical preprocessing step to improve the results of later processing (for example, edge detection on an image). Median filtering is very widely used in digital image processing because under certain conditions, it preserves edges whilst removing noise. The main idea of the median filter is to run through the signal entry by entry, replacing each entry with the median of neighboring entries. Note that if the window has an odd number of entries,then the median is simple to define: it is just the middle value after all the entries in the window are sorted numerically. For an even number of entries, there is more than one possible median. The median filter is a robust filter . Median filters are widely used as smoothers for image processing, as well as in signal processing and time series processing. A major advantage of the median filter over linear filters is that the median filter can eliminate the effect of input noise values with extremely large magnitudes. (In contrast, linear filters are sensitive to this type of noise - that is, the output may be degraded severely by even by a small fraction of anomalous noise values) . The output y of the median filter at the moment t is calculated as the median of the input values corresponding to the moments adjacent to t:

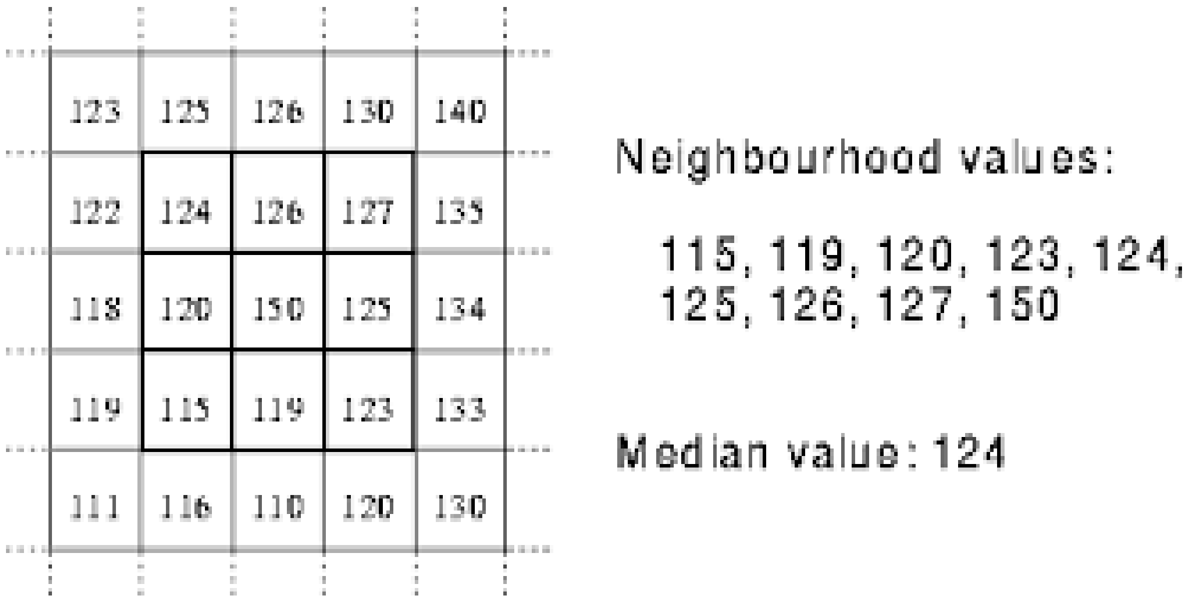
$$y(t) = median((x(t-T/2),x(t-T1+1),\dots,x(t),\dots,x(t+T/2))$$

where t is the size of the window of the median filter. Besides the one-dimensional median filter described above, there are two-dimensional filters used in image processing .Normally images are represented in discrete form as two dimensional arrays of image elements, or "pixels" - i.e. sets of non-negative values Bij ordered by two indexes –

i =1,…, Ny (rows) and j = 1,…,Ny (column)

where the elements Bij are scalar values, there are methods for processing color images, where each pixel is represented by several values, e.g. by its "red", "green", "blue" values determining the color of the pixel.

Like the **mean filter**, the median filter considers each pixel in the image in turn and looks at its nearby neighbors to decide whether or not it is representative of its surroundings. Instead of simply replacing the pixel value with the mean of neighboring pixel values, it replaces it with the median of those values. The median is calculated by first sorting all the pixel values from the surrounding neighborhood into numerical order and then replacing the pixel being considered with the middle pixel value. (If the neighborhood under consideration contains an even number of pixels, the average of the two middle pixel values is used.) Figure 1 illustrates an example calculation.



Calculating the median value of a pixel neighborhood. As can be seen, the central pixel value of 150 is rather unrepresentative of the surrounding pixels and is replaced with the median value: 124. A 3×3 square neighborhood is used here --- larger neighborhoods will produce more severe smoothing.

3-3-3 Removing Noise By Adaptive Filtering

The goal of the Wiener filter is to filter out noise that has corrupted a signal. It is based on a statistical approach. Typical filters are designed for a desired frequency response. The Wiener filter approaches filtering from a different angle. One is assumed to have knowledge of the spectral properties of the original signal and the noise, and one seeks the LTI filter whose output would come as close to the original signal as possible . Wiener filters are characterized by the following:

a. Assumption : signal and (additive) noise are stationary linear random processes with known spectral characteristics.

b. Requirement : the filter must be physically realizable, i.e. causal (this requirement can be dropped, resulting in a non-causal solution)

c. Performance criteria : minimum mean-square error.

CHAPTER FOUR

RESULTS

4-1 Results

in this research we used cameraman image in (tif) format apply on it 4 types of noise and filtered the noisy images by using .three filters (mean ,median and wiener).

The used noise are :-

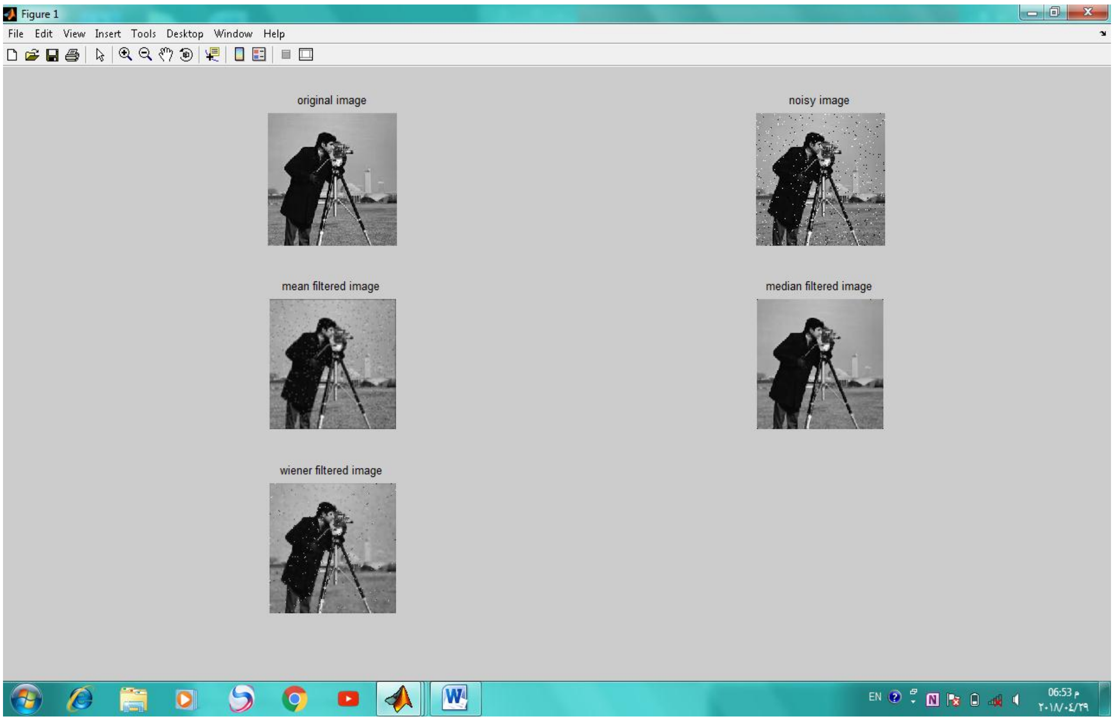
1- Salt&pepper noise.

2- Poisson noise.

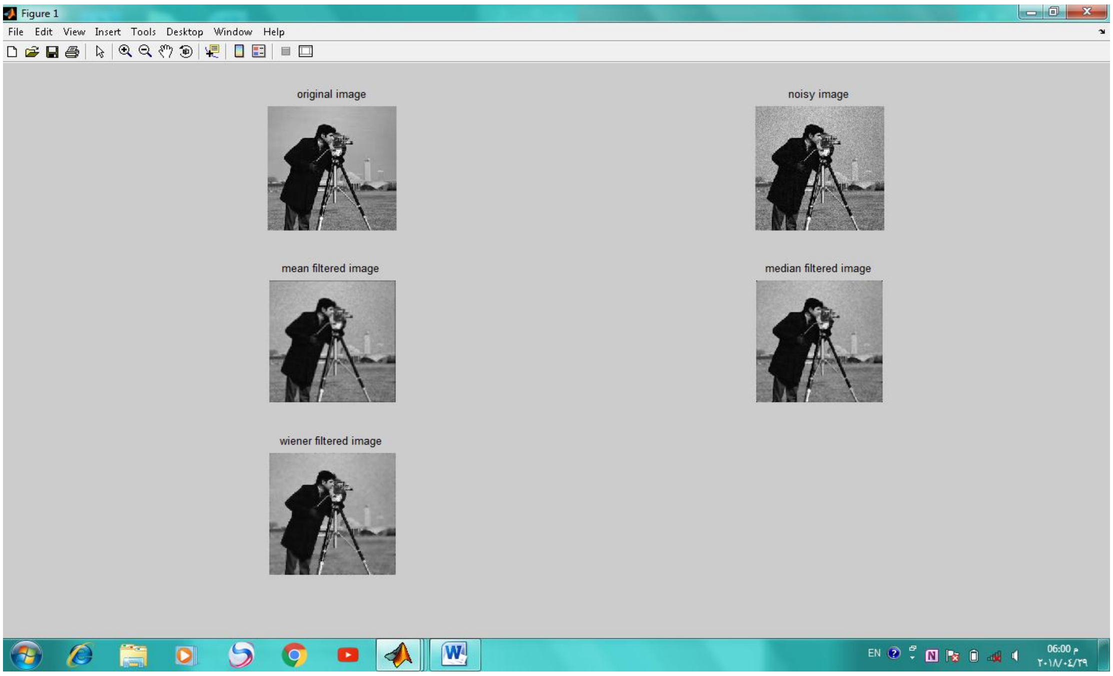
3- Gaussian noise.

4- Speckle noise.

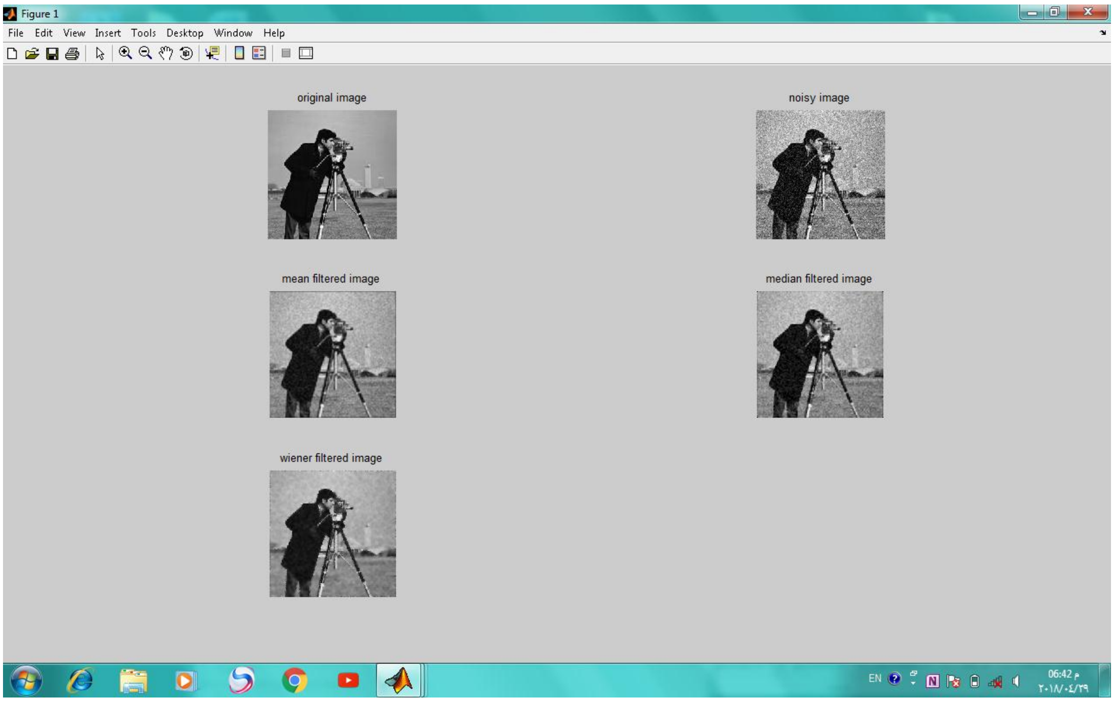
1-When we add salt & pepper noise.



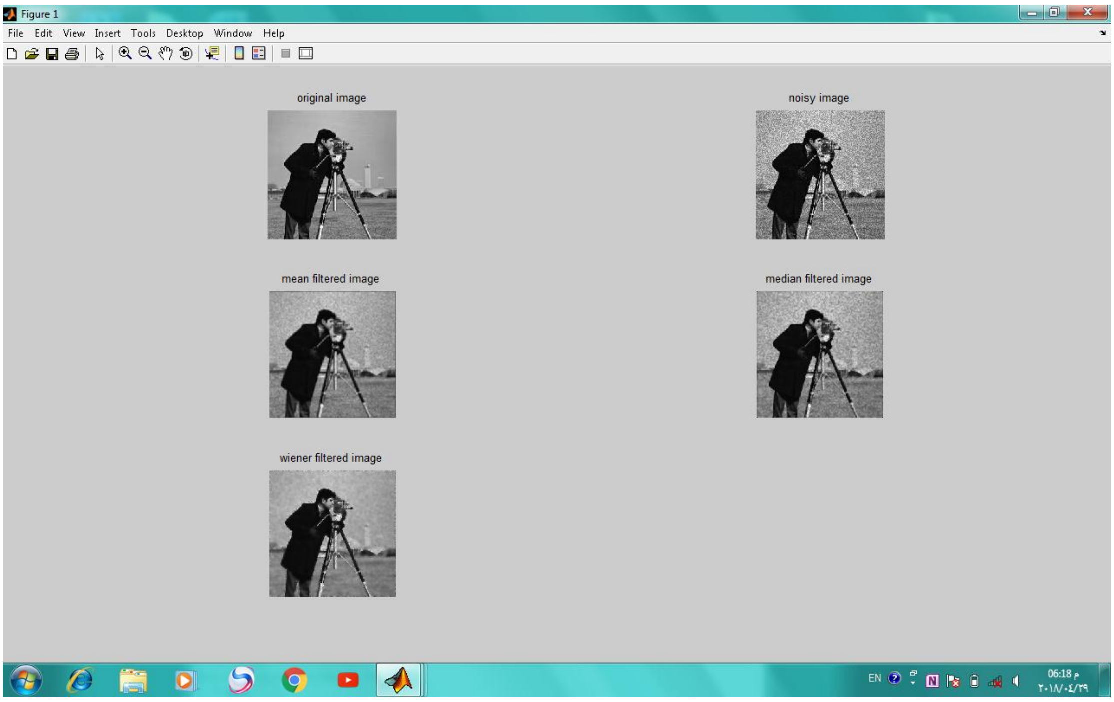
2-When we add Poisson noise.



3-When we add Gaussian noise.



4- When we add Speckle noise.



4-2 Performance analysis

Here the quantitives analysis are Peak Signal to Noise Ratio (PSNR) and Mean Square Error (MER).

Types of noise	K Mean Filter	L Median Filter	M Wenier Filter
Salt& pepper	MSE 236,3 PSNR 24,396	MSE 17,832 PSNR 35,619	MSE 32,948 PSNR 32,952
Gaussian	MSE 236,3 PSNR 24,396	MSE 29,045 PSNR 33,5	MSE 19,11 PSNR 35,318
Speckle	MSE 236,3 PSNR 24,396	MSE 58,783 PSNR 30,438	MSE 36,119 PSNR 32,553
Poisson	MSE 236,3 PSNR 24,396	MSE 30,008 PSNR 33,358	MSE 28,174 PSNR 33,632

Comparison of various filters on different types of noise using cameraman image.

CHAPTER FIVE

CONCLUSION

5-1 conclusion

Its size has to be uneven, so that it has a center, for example 3x3, 5x5 and 7x7 are ok. It doesn't have to, but the sum of all elements of the filter should be 1 if you want the resulting image to have the same brightness as the original. If the sum of the elements is larger than 1, the result will be a brighter image, and if it's smaller than.

1- Image filtering is useful for many applications, including smoothing, sharpening, removing noise, and edge detection. A filter is defined by a kernel, which is a small array applied to each pixel and its neighbors within an image.

2- the result will be a brighter image, and if it's smaller than 1, a darker image. If the sum is 0, the resulting image isn't necessarily completely black, but it'll be very dark.

3- We use (Tulips) format ,adding four noise (Speckle, Gaussian, Poisson and Salt & Pepper),) in original image with standard deviation(0.025),De-noised all.

noisy images by all filters and conclude from the results that :

(a) The performance of the Wiener Filter after de-noising for all Speckle, Poisson and Gaussian noise is better than Mean filter and Median filter.

(b) The performance of the Median filter after de-noising for all Salt & Pepper noise is better than Mean filter and Wiener filter.

5-2 SCOPE FOR FUTURE WORK

There are a couple of areas which we would like to improve on One area is in improving the de-noising along the edges as the method we used did not perform so well along the edges. Another area of improvement would be to develop a better optimality criterion as. The future work of research would be to implement Wiener Filter in Wavelet Domain, applying the methods in which the noise variance is known & in which the noise variance is unknown i.e.

the MAD method

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