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IJIEMR Transactions, online available on 24th Apr 2022. Link :http://www.ijiemr.org/downloads.php?vol=Volume-11&issue=ISSUE-04

DOI: 10.48047/IJIEMR/V11/I04/93

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Volume 11, Issue 04, Pages: 584-593

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A COMPARATIVE ANALYSIS OF DIFFERENT DENOISINGTECHNIQUES FOR MEDICAL IMAGES

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ABSTRACT

Now a day's images are used in various medical science applications. Medicalimages are analyzed for the diagnosis of various diseases like cancer, tumor and fractureetc. But, they are susceptible to different types of noises like Gaussian noise, Specklenoise, salt and pepper noise, etc.,. Noisy images reduces the image contrast, edges,textures, object details and resolution. Therefore it is an important task to remove thenoise from medical images especially in MRI, CT, PET, SPECT, Digital Mammogramand Ultrasound images. Selection of appropriate filter is a tough task. In this project, wemainly compare different denoising techniques to remove the noise like gaussian noise,salt and pepper noise, and speckle noise. Several filtering techniques can be used forremoving the noise so that visual quality is improved. We have done a comparativestudy of different denoising techniques in order to validate and analyze by using PSNRand SSIM parameters. In this comparative study we have used many medical images.we have performed all these techniques on same image and compared the results toprove which technique is better for which noise and results are reported

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1. INTRODUCTION

Image Processing

An image may be defined as a two-dimensional function, f(x, y), where x and yare spatial (plane) coordinates, and the amplitude of f at any pair of coordinates (x, y) iscalled the intensity or gray level of the image at that point. When x, y, and the amplitude values of f are all finite, discrete quantities, we call the image a digital image.The field of digital image processing refers to processing digital images by means of adigital computer. Note that a digital image is composed of a finite number of elements,each of which

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has a particular location and value. These elements are referred to aspicture elements, image elements, pels, and pixels. Pixel is the term most widely used todenote the elements of a digital image.

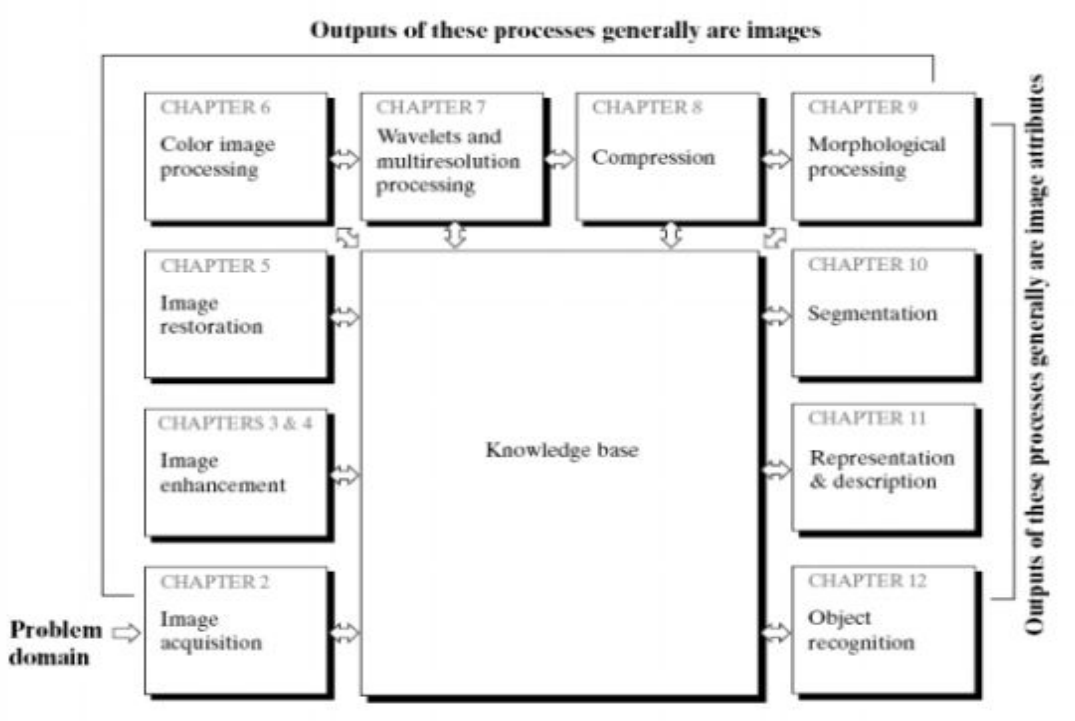

Fig: Block diagram of image processing

INTRODUCTION TO NOISES:

Noise is always presents in digital images during image acquisition, coding,transmission, and processing steps. It is very difficult to remove noise from the digitalimages without the prior knowledge of filtering techniques .Here, we will get a briefoverview of various noise and the filtering techniques . These filters can be selected byanalysis of the noise behavior. In this way, a complete and quantitative analysis of noiseand their best suited filters will be presented.Image noise is random variation ofbrightness or color information in images, and is usually an aspect of electronic noise. Itcan be produced by the image sensor and circuitry of a scanner or digital camera. Imagenoise can also originate in film grain and in the unavoidable shot noise of an idealphoton detector.

Sources of Image noise

• While image being sent electronically from one place to another.

• Sensor heat while clicking an image.

• With varying ISO Factor which varies with the capacity of camera to absorblight.

TYPES OF NOISES:

The process which attempt to remove the noise from the image and restore thequality of the

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original image is known as Image Restoration. This is an importantaspect in maintaining the quality of the image by restoring the pixel value. Restorationtechniques are a model for linear image degradation and it is the opposite process toimprove the quality of original image. To obtain an optimal estimate of the desiredresult restoration technique involves mathematically principle of goodness which helpsto achieve. There are different types of noises in medical images. Noises is anunacceptable signal that changes the property and performance of the signal. Theimages are corrupted by following noises like:

1.Gaussian Noise

2.Salt and Pepper Noise

3.Speckle Noise

GAUSSIAN NOISE:

Gaussian Noise is a statistical noise having a probability density function equal tonormal distribution, also known as Gaussian Distribution. Random Gaussian function isadded to Image function to generate this noise. It is also called as electronic noisebecause it arises in amplifiers or detectors. Source: thermal vibration of atoms anddiscrete nature of radiation of warm objects.

This noise is removed from the digital images by smoothening of the imagepixels which helps in reducing the intensity of the noise present in the image which iscaused due to acquisition but the result maybe sometime undesirable and also which canresult in blurring edges of the high-quality images .Gaussian noise is generally calledenhancer noise or random variation impulsive noise. Gaussian noise is created by

(a) Electronic circuit noise,

(b) Sensor noise because of high temperature,

c) Sensor noise due to poor brightening.

Gaussian noise is arising in electronic components which is normally known aselectronic noise. It is the demographically noise to that of the original distribution. Thenoise is independent of each pixel as well as signal intensity and is preservative innature .

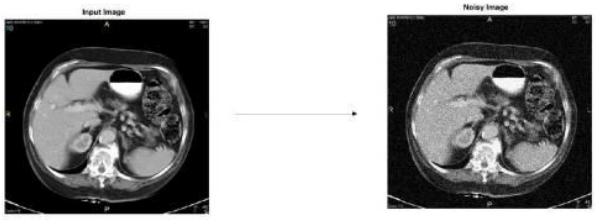

Fig: Original to gaussian noisy image

SALT AND PEPPER NOISE:

Salt and pepper noise is called impulse noise.There are three types of impulsenoises. Salt Noise, Pepper Noise, Salt and Pepper Noise.Salt Noise: Salt noise is added to an image by addition of random bright (with 255 pixelvalue) all over the image.Pepper Noise: Salt noise is added to an image by addition of random dark (with 0 pixelvalue) all over the image.Salt and Pepper Noise: Salt and Pepper noise is added to an image by addition of bothrandom bright (with 255 pixel value) and random dark (with 0 pixel value) all over theimage.This model is also known as data drop noise because statistically it drop theoriginal data values .It can generally be named as a spike noise. The salt and pepper noise is broughtabout by sudden and sharp disorder in the image signal. It is apparent as arbitrarilyscattered dark or white (or together) pixels above the image. The S&P noise affectedpixel has two possible values. The

value of white pixel or salt pixel is 255. The value ofblack or pepper pixel is 0. The noisy (S&P) images must be a 8-bit grayscale image. Itis digitized as great quality in the image. Impulse noise contained image has dark pixelsin the bright region.

The image which is low in quality has bright and dark pixels present in it whichcauses noise in it also referred as Salt Pepper noise. An image which contains SaltPepper noise will generally have bright pixels in dark portion and dark pixels in brightportion of the image. Black and white dots appear in the image as a result of this noise.Due to sharp and unexpected changes of image signal the noise arises. Dead pixels,analog-to-digital converter errors, bit errors in transmission, etc. are caused due to thepresence of Salt Pepper noise in the image. This kind of noise can be removed by usingDark Frame Subtraction (DFS) and by constructing new data points around dark andbright pixels which is obtained by the Median filter or morphological filter.

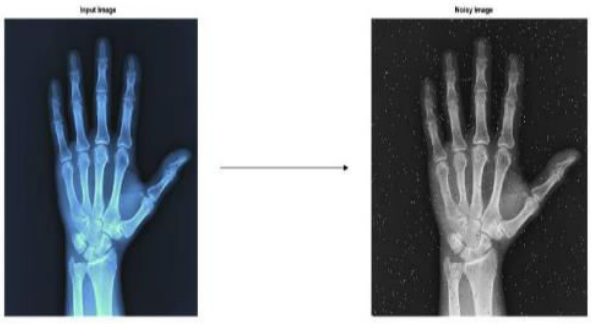

Fig:Original to salt and pepper noisy image

SPECKLE NOISE:

Another type of noise which corrupts the quality of the active radar, medicalimages and optical coherence tomography images is known as speckle noise. The majorcause of speckle noise generation is the effect of environmental conditions duringimaging sensor in the process of image transmission.

Speckle is a granular noise that inherently exists in an image and degrades itsquality. Speckle noise can be generated by multiplying random pixel values withdifferent pixels of an image.Speckle noise expands the mean gray near a native area andcausing difficulties in medical images because of the coherent processing of backscattered signals.

The Speckle Noise is defined as a noise which is present in the images andwhich degrades the quality of an image. Speckle Noise is a phenomenon that convoysall coherent imaging modal quality in which images are produced by interfering echoesof a transmitted waveform that originate from diversity of the studied objects.

These arethe granular noises that are fundamentally present in the image and reduce the quality ofthe active radar and Synthetic Aperture Radar (SAR) images or Magnetic Resonance .Imaging (MRI) images is referred to as Speckle Noise.

If Speckle Noise is present in the conventional radar results from randomvariations in the return signal from an object which is no longer image process signalincreases the mean grey level in an image. A Speckle Noise is the coherent imaging ofobjects in the image.

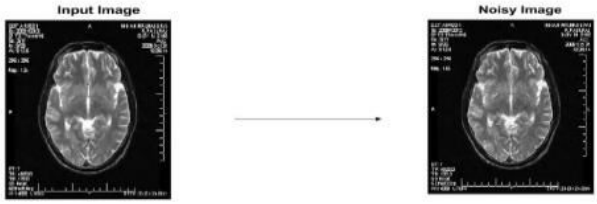

Fig:Original to speckle noise image

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2. LITERATURE SURVEY

IMAGE DENOISING:

Image denoising is to remove noise from a noisy image, so as to restore the trueimage. However, since noise, edge, and texture are high frequency components, it isdifficult to distinguish them in the process of denoising and the denoised images couldinevitably lose some details. Overall, recovering meaningful information from noisyimages in the process of noise removal to obtain high quality images is an importantproblem nowadays.

In fact, image denoising is a classic problem and has been studied for a longtime. However, it remains a challenging and open task. The main reason for this is thatfrom a mathematical perspective, image denoising is an inverse problem and its solutionis not unique. In recent decades, great achievements have been made in the area ofimage denoising [1,2,3,4], and they are reviewed in the following sections.

DENOISING METHODOLOGIES:

There are three basic approaches to image denoising

Spatial Filtering,

Transform Domain Filtering and

Wavelet Thresholding Method.

Objectives of anyfiltering approach are:

• To suppress the noise effectively in uniform regions.

• To preserve edges and other similar image characteristics.

•To provides visually natural appearance

SPATIAL FILTERING:

A traditional way to remove noise from image data is to employ spatial filters.spatial filtering is the method of choice in situations when only additive noise is present.It can be further classified into 2 categories:

1. Linear filters and

2. Non-Linear Filters

TRANSFER DOMAIN FILTERING:

The transform domain filtering can be divided according to the choice of basicfunctions. They mainly classified into

non- data adaptive transform

and dataadaptive transform

WAVELET DOMAIN FILTERING:

Working in Wavelet domain is preferred because the Discrete WaveletTransform (DWT) make the signal energy concentrate in a small number ofcoefficients, hence, the DWT of the noisy image consists of a small number ofcoefficients having high Signal to Noise Ratio (SNR) while relatively large number ofcoefficients is having low SNR. After removing the coefficients with low SNR (i.e.,noisy coefficients) the image is reconstructed by using inverse DWT. As a result, noiseis removed or filtered from the observations. A major advantage of Wavelet methods isthat it provides time and frequency localization simultaneously.

3. PROPOSED WORK

Comparative analysis of Denoising methods

OVERVIEW OF WORKING PROCESS

Noise is caused due to various sources which include many external causes intransmission system and environmental factors which includes noise like Gaussian,Poisson , Blurred , Speckle and salt-and-pepper noise. Noise removing method hasbecome an important factor in medical imaging applications and the most commonlyused filters are Median filter,

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Gaussian filter, Weiner filter which gives the best resultfor the respective noises.

The need for the smoothening of images has becomes essential which is requiredto remove the noise and for that best filters or standard filters are used in most of theimage processing applications. The important asset of a good image de-noising model isto remove the noise from the image and also preserve the edges. There are two types ofmodels which are used for de-noising i.e. linear model and non-liner model andgenerally, linear models are used because of its speed and limitation is that it is not ableto preserve the edges in an efficient manner.These data is observed by using filters and finding out the best filter on the basisof the histogram, size and clarity of the MRI images given to these filters.

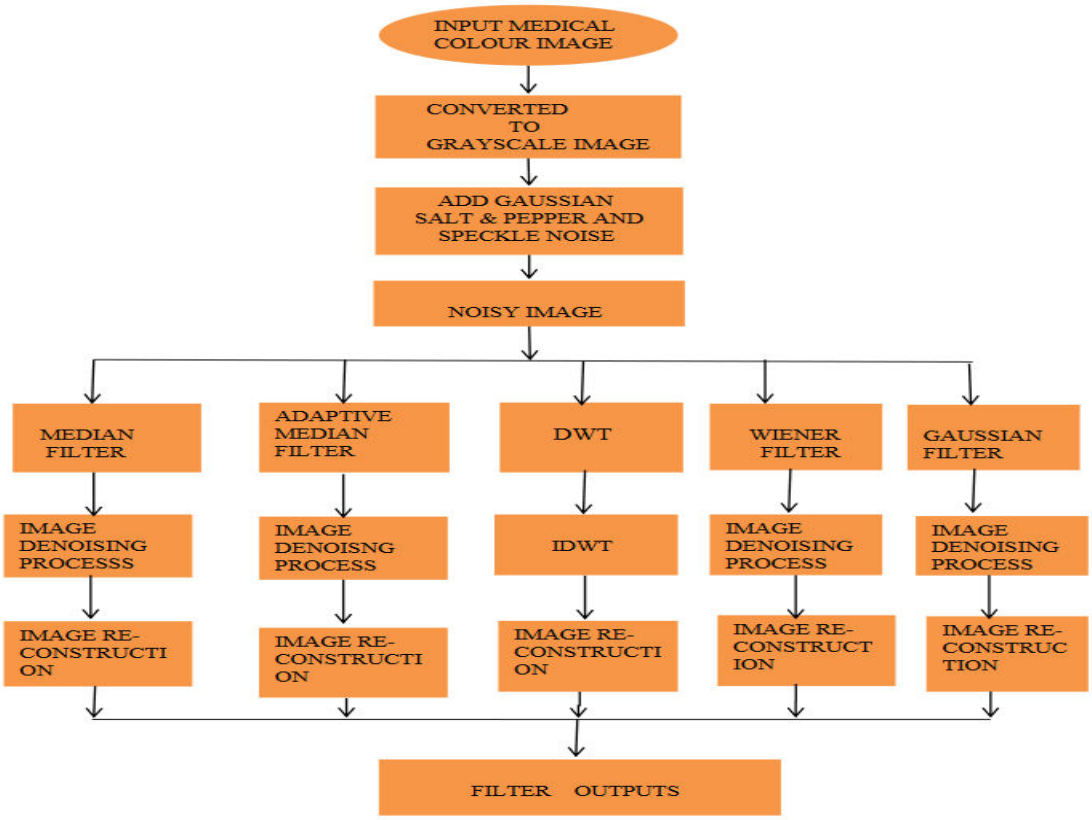

Fig : Flow chart of work flow

DENOISING TECHNIQUES

The method used in digital image processing aims at the deletion of noise, whichcan corrupt an image during its acquire or programming process, which may touch itsquality while recalling. The images normally have a problem of great level of noisycomponents. Medical image denoising know-how has attracted the usage of moremedical equipment usage. The Main purpose of medical image de-noising to solveissues of high level noise of a medical

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image.

Nowadays wavelet transform (WT) is used due for denoising due to its excellentlocalization property. There are different methods for elimination of noises. All theconventional methods have so many disadvantages which does not analyze the non-stationary signal. In this consignment we advise an alternate method for de-noising theimages using wavelet transform using MATLAB software. This technology is morecapable by considering its nearby wavelet quantities, with different values. Thethreshold estimation is carried out by developing the standard deviation, arithmeticmean and geometrical mean of the input image.

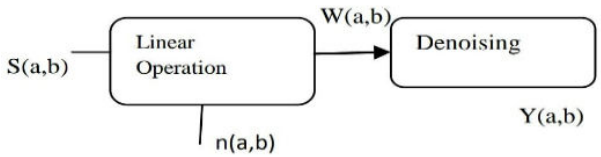

Fig : Basic de-noising concept

Here denoising techniques means filters which removes the noise and restoresthe image with a good quality.Different types of filters are used to remove differenttypes of noises. A filter is the one that removes the unwanted signal or some randomnoise and improves the image quality of the image for the better understanding.

TYPES OF FILTERS:

In the recent years the big challenge for the researcher to de-noise the image torecover the existing image which was corrupted or blurred. It is necessary step usedbefore the image detail is analyzed. It is important to use a better denoising method torecover the image from the data corruption. Filters are data processing techniques thatcan smooth out high-frequency fluctuations in data or remove periodic trends of aspecific frequency from data. In MATLAB, the filter function filters a vector of data xaccording to the following difference equation, which describes a tapped delay-linefilter.

There are two sorts of filters:

1. Linear Filters

2. Non-linear Filters with their noteworthy favorable circumstances and disservices.

The linear filters have the benefit of speedier planning and the shortcoming ofnot sparing edges. A fact in non-linear filters has the upside of securing edges and thedownside of slower preparation. In this work, four kinds of filters have been talkedabout underneath which will be utilized further to obliterate the noise information fromthe main image.

Here we are using different types of filters to remove noise. We mainly focus on fivedifferent filters that remove the noise.

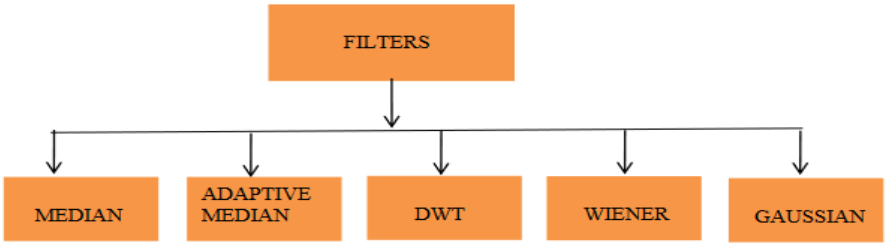

Fig: Types of Filters

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MEDIAN FILTER:

It is a non-linear filtering technique. Median filter is widely used in digital imageprocessing, under certain conditions. It preserves edges while removing the noise.Themedian filter works moving through the image pixel by pixel replacing each value bythe median of the neighboring pixels value. The patterns of the neighborsis known as‘window’ which slides pixel by pixel over the entire image. It effectively suppresses theimpulsive noise or salt & pepper noise.

ADAPTIVE MEDIAN FILTER:

Adaptive filtering is an improved filtering technique as compare to median filterin which the filtering is applied only to corrupted pixels in the image while theuncorrupted pixels are left unchanged. The Adaptive filtering approach is used to reducethe number of noisy pixels during filtering.

DISCRETE WAVELET TRASNFORM (DWT):

The discrete wavelet transforms (DWT) is an effective and useful tool fordecomposing the 2D signal. It provides the time and frequency domain representation.The development of discrete wavelet (DWT) was to overcome the short coming of theShort time Fourier transform (STFT), the use of that to analyses non-stationary signals.A set of mutually orthogonal wavelet basis functions are generated when the Discretewavelet transform (DWT) decomposes a given signal. The discrete wavelet transform isinvertible, so that the original image can be recovered from its discrete wavelettransform (DWT) representation.

WIENER FILTER:

A Wiener filter which is a flexible low-pass filter uses pixel wise adoption. Thisis an adaptive filtering method with linear in nature. The method used in wiener filter isa statistics approximation-based approach from nearer of each pixel. The mainadvantage of this filter is that it preserves the edges of an image.

GAUSSIAN FILTER:

Gaussian filter is implemented to remove the Speckle Noise present in ultrasound images or MRI brain images. Speckle Noise is typical noises which is caused dueto internal or external factor and are generally present in the digital images and MRIimages. In this technique, the average value of the surrounding pixel or neighboringpixels replaces the noisy pixel present in the image which is based on Gaussiandistribution. Gaussian filter is a linear smoothing filter, where the weights are chosenfor the smoothing purpose according to the outline of the function of Gaussian.

ANALYSIS:

FILTERS	PSNR	SSIM
MEDIAN	14.3964	0.3535
ADAPTIVE MEDIAN	14.9414	0.3150
DWT	18.3398	0.4354
WIENER	**18.6821**	**0.5147**
GAUSSIAN	17.6142	0.4478

Table: Gaussian noise PSNR and SSIM values

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FILTERS	PSNR	SSIM
MEDIAN	15.0164	0.7331
ADAPTIVE MEDIAN	16.5785	**0.7994**
DWT	15.3680	0.3328
WIENER	**17.4468**	0.4201
GAUSSIAN	17.3205	**0.4255**

Table: salt and pepper noise PSNR and SSI

FILTERS	PSNR	SSIM
MEDIAN	14.9876	0.6202
ADAPTIVE MEDIAN	16.5654	0.6691
DWT	22.4905	0.7980
WIENER	**23.1679**	**0.8338**
GAUSSIAN	21.3661	0.8046

Table: Speckle noise PSNR and SSIM values

4. CONCLUSION

In this work we have taken different medical images like MRI, CT, X-RAY foranalyzing the noise removal techniques. We have added Salt & Pepper, Gaussian, andspeckle noise to applied filtering techniques like Median Filtering, adaptive medianFiltering, DWT, wiener filtering and gaussian filter to remove the noises. The results ofnoises are analyzed and compared with the performance metrices such as SSIM andPSNR and also evaluated through the quality pixels, size, clarity and histogram of theseimages. Through this work we have observed that the choice of filters for de-noising themedical images depend on the type of noise and type of filtering technique, which areused. From the simulation, Median filter and adaptive median filter gives best resultsfor Salt and Pepper noise. Wiener filter suits best for Gaussian and Speckle Noise.Gaussian filter suits best for Gaussian Noise images. Comparative results of all filtersused for denoising are shown for gaussian, salt and pepper and speckle noises whichwas applied on same image.

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