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Noise Removal and Filtering Techniques used in Medical Images

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ABSTRACT

Noise removal techniques have become an essential practice in medical imaging application for the study of anatomical structure and image processing of MRI medical images. To report these issues many de-noising algorithm has been developed like Weiner filter, Gaussian filter, median filter etc. In this research work is done with only three of the above filters which are already mentioned were successfully used in medical imaging. The most commonly affected noises in medical MRI image are Salt and Pepper, Speckle, Gaussian and Poisson noise. The medical images taken for comparison include MRI images, in gray scale and RGB. The performances of these algorithms are examined for various noise types which are salt-and-pepper, Poisson, speckle, blurred and Gaussian Noise. The evaluation of these algorithms is done by the measures of the image file size, histogram and clarity scale of the images. The median filter performs better for removing salt-and-pepper noise and Poisson Noise for images in gray scale, and Weiner filter performs better for removing Speckle and Gaussian Noise and Gaussian filter for the Blurred Noise as suggested in the experimental results.

Keywords: Weiner Filter, Median Filter, Gaussian Filter, Speckle noise, Salt and Pepper noise, Gaussian noise, Poisson noise, blurred noise.

INTRODUCTION

Noise is caused due to various sources which include many external causes in transmission system and environmental factors which includes noise like Gaussian, Poisson, Blurred , Speckle and salt-and-pepper noise. Noise removing method has become an important factor in medical imaging applications and the most commonly used filters are Median filter, Gaussian filter, Weinerfilter which gives the best result for the respective noises.

The need for the smoothening of images has becomes essential whichis required to remove the noise and for that best filters or standard filters are used in most of the image processing applications. The property of a de-noising model is to remove the noise from the image and also preserve the edges. There are two types of models which are used for de-noising linear model and non-liner model. Most of the time linear models are experimented because of its speed even though it has the limitation of not able to preserve the edges of an image in a efficient way.

These data is observed by using filters and finding out the best filter on the basis of the histogram, size and clarity of the MRI images given to these filters.

Removal Techniques

Image de-noising is assetfor image noise processing which includes filtering techniques which includes different ways to de-noise an image. It is solved by using different algorithms. Accordingly, noises are spotted with neighboring information and are removed using best filtering techniques without affecting the image quality and reinforce the smoothness of the image taken for examination.

Median Filter

The Median filter is nonlinear technique which is known as order-statistic filtering in digital image processing. Median filter is very popular technique for the removal of impulse noisebecause it runs through the signal cell by cell and replacing the value of each cell with the neighboring by a median of the intensity levels with its mathematical accuracy. The outcome of neighborhood pixels by the Median Filter in an image is done by the static filtering window size which slides cell by cell over the signal. The technique is applied across the image and therefore ittends to transform both noisy and de-noised pixels present in the image. Due to this tendency of median filter the good pixels cell are replaced by the corrupted ones. Therefore, de-noising often leads to removal of fine details present in an image because it is done at the cost of distorted and blurred features possessed by the this filtering technique.

Weiner Filter (WF)

The goal of the Weiner filter is tofilter out the noisepresent in an image which posses corrupted signal in it. This filtering technique uses statistical approach to filter the noise from each pixel of an image.This filteringtechnique uses different angle in an image to modify the corrupted signal in it. Original image signal has spectral properties and noise present in it so to start with experiment one should have the knowledge of the properties of it, one seeks the LTI filter (Linearity and Time-Invariance) whose outcome will be closer to the original signal present in the image as achievable. Wiener filter is a technique which performs optimal trading involving opposite filtering and noise smoothing. It removes the blurring and additional noise present in the image and it is also very optimal in relation to the mean squared error where it minimizes the overall Mean Square Error in the operation of the filtering technique for noise removal[1].

Wiener filters are usually defined by the following:

a. Hypothesis: additive noise and image signal are inactive linear random processes containing spectral characteristics.
b. Necessity: The filter must be able to achieve and can be accessed.
c. Performance criteria: It depends on minimum Mean Square Error.

Gaussian filter

Speckle Noise is typical noises which is caused due to internal or external factor and are generally present in the digital images and MRI images. Gaussian filter is implemented to remove the Speckle Noise present in ultra sound images or MRI brain images. In this technique, the average value of the surrounding pixel or neighboring pixels replaces the noisy pixel present in the image which is based on Gaussian distribution.

Different type of noise in Medical images

The process which attempt to remove the noise from the image and restore the quality of the original image is known as Image Restoration. This is an important aspect in maintaining the quality of the image by restoring the pixel value. Restoration techniques area model for linear image degradation and it isthe opposite process to improve the quality of original image. To obtain an optimal estimate of the desired result restoration technique involves mathematically principle of goodness which helps to achieve.

Gaussian Noise

Gaussian distribution which is also known as normal distribution whose Probability Density Function is equal to statistical noise known as Gaussian Noise. This noise is removed from the digital images by smoothening of the image pixels which helps in reducing the intensity of the noise present in the image which is caused due to acquisition but the result may be sometime undesirable and also which can result in blurring edges of the high-quality images[2].

The formula of adding the Gaussian Noise to an image is:
g = imnoise (I,'Gaussian', m, var), where I is the input image, m is mean and var is variance.

Salt Pepper Noise

The image which is low in quality has bright and dark pixels present in it which causes noise in it also referred as Salt Pepper noise. This noise will generally have bright pixels in dark portion and dark pixels in bright portion of the image.Black and white dots appear in the image[3] as a result of this noise shown in the fig 10(a). Due to sharp and unexpected changes of image signal the noise arises and causes dead pixels, analog-to-digital converter errors, etc. in the image. This kind of noise can be removed by using Dark Frame Subtraction (DFS) and by constructing new data points around dark and bright pixels which is obtained by the Median filter or morphological filter[4].

Speckle Noise

The Speckle Noise is defined as a noise which is present in the images and which degrades the quality of an image. Speckle Noise is a incident that convoys all rational imaging model quality in which images are formed by inquisitive echoes of a mediate waveform that originate from diversity of the studied objects[5].These are the granular noises that are fundamentally present in the image and reduce the quality of the active radar and Synthetic Aperture Radar (SAR) images or Magnetic Resonance[6].Imaging (MRI) images is referred to as Speckle Noise. If Speckle Noiseis present in the images then it results in the random variations ofthe return signal which increases the grey level in an image. A Speckle Noise is the coherent imaging of objects in the image. In fact, it is caused due to errors in data transmission. This kind of noise affects the ultrasound images and MRI images.

Speckle Noise follows a gamma distribution and is given as:
(g) = [5ØTÜ5ØTÜ"""1 ("""1)! 5Øþ<5ØNÜ""
e"5ØTÜ5ØTÜ5ØNÜ5ØNÜ]

Where, "" is the shape parameter of gamma distribution, 'a' is the variance and 'g' is the gray level.

Poisson Noise

Poisson Noise is a electronic noise which is a form of ambiguity related with the quantity of the light. This occurs in an image when the limited number of particles that carry energy, such as electrons which is small enough to give rise to measurable variations. Consider a light combination of photons coming out of a source and striking a point which creates a evident spot, the physical process which governs the light emission are such that those photos which are emitted from the light source hits the point many times but to create visible spot billions of photons are needed. However, if the source is not able to emit handful number of photons which hits the point every second then this noise is caused.

The formula of adding the Gaussian Noise to an image is:
J = imnoise (I,'poisson') where I is double precision, then input pixel values are interpreted as means of Poisson distributions.

Blurred Noise

Blurred Noise is caused due to the light intensity and external factors. Capturing reasonable photos under low light conditions using a hand-held camera can be annoying experience. Often the photos taken are blurred or noisy. These kinds of images containing hazy and blurred pixels are referred to as Blurred Noise which is present in the image.

Literature Review

Noise reduction is a very essential step in digital image processing for getting better quality images. Medical imaging is a valuable tool in the field of medicine. Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Ultra Sound imaging (USI) and other imaging techniques provide more effective information about the anatomy of the human body, during the diagnosis process[9]. In the medical field the Surgeons always desire for enhanced medical images for the diagnosis because most of the time the images are not perfect and are deteriorated by many internal and external factors. The low quality of medical images causes difficulty for the Surgeons at the time of diagnosis or interpretation. A quality image is needed by Biometric Identification and Authentication Systems to aim at consistent and exact outcomes so that it can be helpful for universal**person trained in medical science** to study the prodrome of the patients. The quality of the MRI and brain imageis obtained by the noise free images to get the better result and increased in accuracy of the result. Many filters are applied to get the best possible result for the noises present in the image like Weiner filter, Median filter etc. Weiner filter and Median filter gives the best result compared to the other filters for the Speckle Noise, Gaussian Noise and Poisson noise as well which are present in an image[10]. Some filters work best for the specific Noises like Salt Pepper, Gaussian, Speckle, Blurred Noise etc. and later in the experiment it will be briefed. The advantage of Median filter is to remove cells which are distant from the observations experimented without reducing the quality of the image and the disadvantage is that while smoothing the noise in the image loses its quality on the edges and boundaries it also erases the details in the image. Gaussian filter advantage is for peak detection and disadvantage is it reduces the details from an image[11].

RESULTS

The implementation of various de-noising algorithms with different filters has been carried out using MATLAB. Here the images considered are MRI brain images, in RGB and gray scale affected by noises like PoissonNoise, Speckle Noise, Gaussian Noise and Salt and Pepper. 20 MRI medical images is been taken for the experiment of the noise and its removal. These images have been processed in the MATLAB by adding different noises to an image.After adding the noise to an image different noise filtering algorithm is used to remove the noise from an image.

Speckle Noise

In medical ultrasound imaging speckle noise is inbuilt property which normally tends to reduce the quality of the image, contrast and pixels.

IMAGES	SPECKLE NOISE				
	WEINER FILTER	MEDIAN FILTER	GAUSSIAN FILTER	MINIMUM VALUE	CLARITY
MRI1	11196	14197	36169	weiner filter	weiner filter
MRI2	9938	13373	34276	weiner filter	weiner filter
MRI3	9862	13281	34117	weiner filter	weiner filter
MRI4	9911	13245	34047	weiner filter	weiner filter
MRI5	9262	12769	31267	weiner filter	weiner filter
MRI6	9179	12765	30878	weiner filter	weiner filter
MRI7	8979	12714	30594	weiner filter	weiner filter
MRI8	8781	12583	29963	weiner filter	weiner filter
MRI9	8410	12287	28492	weiner filter	weiner filter
MRI10	8359	12288	28101	weiner filter	weiner filter
MRI11	8103	12204	26932	weiner filter	weiner filter
MRI12	11124	14088	36068	weiner filter	weiner filter
MRI13	7634	12063	25711	weiner filter	weiner filter
MRI14	10783	13773	35544	weiner filter	weiner filter
MRI15	10391	13571	35099	weiner filter	weiner filter
MRI16	10219	13472	34727	weiner filter	weiner filter
MRI17	10073	13357	34421	weiner filter	weiner filter
MRI18	10069	13491	34633	weiner filter	weiner filter
MRI19	9741	13121	33954	weiner filter	weiner filter
MRI20	9737	13337	33922	weiner filter	weiner filter

Fig. 1: Speckle Filtered Image size given by three filters

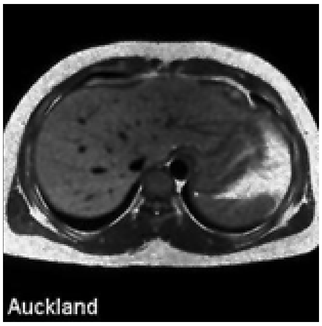
This property which is present in the noise causes the reduction the analytical value of the imaging technique[7]. As per the experiment, the best result on Speckle Noise was achieved by the Weiner filter[8]. First of the noise which was added was Speckle Noise to the 20 MRI images shown in the Fig 2(a). The noise which damages the quality of active radar, Medical Ultrasound, MRI images and Synthetic Aperture Radar is a granular noise which is known as Speckle Noise.

Filters used for theSpeckle Noise were Weiner filter, median filter and Gaussian filter. The minimum size value for the filtered image is given by Weiner filter and clarity is also noted in fig 2 (b).

Blurred Noise

Second of the noise which is added to the image is Blurred Noise using function provided by MATLAB tool. The function which adds noise is J = imnoise (I,'n',M,V) where n is noise present, mean m and variance v to the image I. The value which is set automatically to the image is zero mean noise with 0.01 varianceshown in the fig 4(a). Blurred Noise is the noise which is present in the image that makes the image blurry, to remove this noise experimented filters are Gaussian filter, Median filter and Weiner filter. The minimum size values given by the filters after filtration are Weiner and Median filter but the clarity is noted by the Gaussian filter shown in the fig 4(b).

(a)



(a)

Fig. 2: (a) Speckle Noise (b) Filtered image

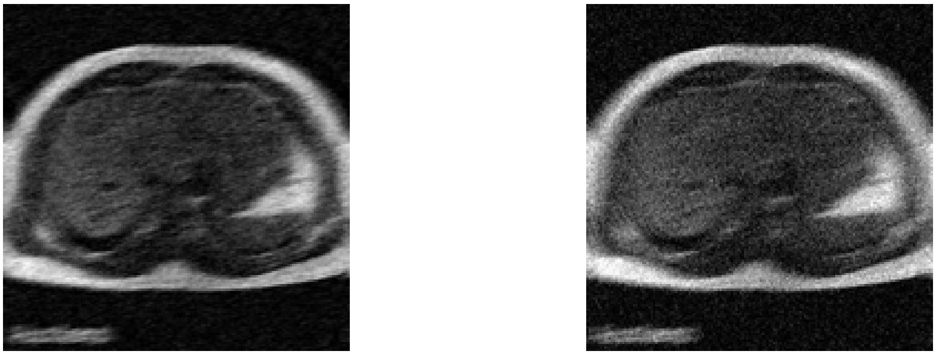
IMAGES	BLURRED NOISE				
	WEINER FILTER	MEDIAN FILTER	GAUSSIAN FILTER	MINIMUM VALUE	CLARITY
MRI1	14197	14051	22627	median filter	gaussian filter
MRI2	13373	19079	21995	weiner filter	gaussian filter
MRI3	13281	14741	21920	weiner filter	gaussian filter
MRI4	13245	13754	21721	weiner filter	gaussian filter
MRI5	12769	13486	19476	weiner filter	gaussian filter
MRI6	12765	11221	19030	median filter	gaussian filter
MRI7	12714	13296	18417	weiner filter	gaussian filter
MRI8	12583	18867	17779	weiner filter	gaussian filter
MRI9	12287	13027	16960	weiner filter	gaussian filter
MRI10	12288	15108	16702	weiner filter	gaussian filter
MRI11	12204	11535	16106	median filter	gaussian filter
MRI12	14088	14420	22617	weiner filter	gaussian filter
MRI13	12063	13090	15244	weiner filter	gaussian filter
MRI14	13773	15240	15048	weiner filter	gaussian filter
MRI15	13571	18951	14508	weiner filter	gaussian filter
MRI16	13472	14727	21375	weiner filter	gaussian filter
MRI17	13357	11610	21852	median filter	gaussian filter
MRI18	13491	11007	21852	median filter	gaussian filter
MRI19	13121	18657	21583	weiner filter	gaussian filter
MRI20	13337	15833	21772	weiner filter	gaussian filter

Fig. 3: Blurred Filtered Image size given by three filters

Gaussian Noise

Third is the Gaussian Noise which is added to the images shown in the fig 6(a). Gaussian distribution which is also known as normal distribution whose probability is equal to statistical noise known as Gaussian Noise. Due to poor illumination andgreat extent of temperature or transmission of particles in an electronic image it fails to meet up the requirement for the clear image this noise is caused. Byusing a Weiner filter this noise can be reduced to very much extent. Same filters are used to check out the best filter for this noise.The best filter was Weiner filter but the minimum size value after using the different filters is given by all three filters shown in fig 5. Each filter is used on all the images, their outcome is noted and compared with the other entire filter applied on the same images. Thecircularly symmetric Gaussian behavior is found in the mellow ultra- sound speckle echo for marginal statistics which is similar to the laser speckle for monochromatic illumination[12].

The result which is achieved showed as follows:



(a) (b)

Fig.4: (a)Blurred MRI image(b) De-blurred Image

IMAGES	Gaussian Noise				
	WEINER FILTER	MEDIAN FILTER	GAUSSIAN FILTER	MINIMUM VALUE	CLARITY
MRI1	14118	14197	13783	gaussian filter	weiner filter
MRI2	13428	13373	13396	median filter	weiner filter
MRI3	13257	13281	13381	weiner filter	weiner filter
MRI4	13355	13245	13281	median filter	weiner filter
MRI5	12839	12769	11421	gaussian filter	weiner filter
MRI6	12713	12765	10927	gaussian filter	weiner filter
MRI7	12663	12714	10633	gaussian filter	weiner filter
MRI8	12563	12583	10118	gaussian filter	weiner filter
MRI9	12415	12287	9573	gaussian filter	weiner filter
MRI10	12453	12288	9344	gaussian filter	weiner filter
MRI11	12111	12204	9025	gaussian filter	weiner filter
MRI12	14049	14088	13767	gaussian filter	weiner filter
MRI13	12106	12063	8498	gaussian filter	weiner filter
MRI14	13887	13773	13475	gaussian filter	weiner filter
MRI15	13462	13571	13162	gaussian filter	weiner filter
MRI16	13472	13472	12779	gaussian filter	weiner filter
MRI17	13357	13357	12793	gaussian filter	weiner filter
MRI18	13491	13491	13472	gaussian filter	weiner filter
MRI19	13121	13121	13138	weiner/median filter	weiner filter
MRI20	13337	13337	13216	weiner/median filter	weiner filter

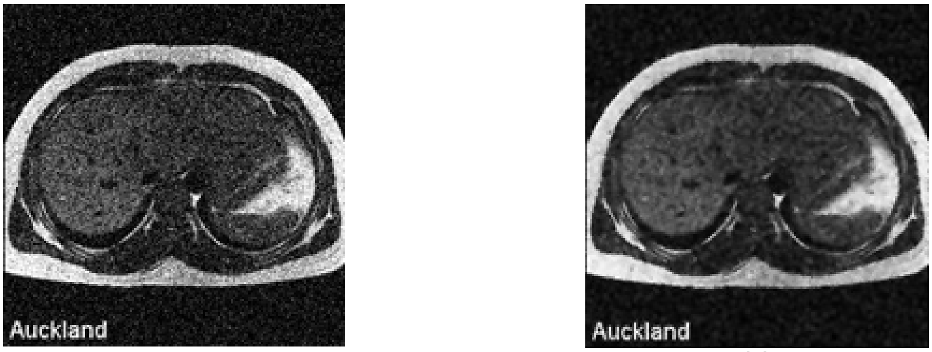
Fig. 5: Gaussian Filtered Image size given by three filters

Poisson Noise

Poisson is also known as shot photon noise is the noise which is caused when sensor is not sufficient to provide detectable statistical information even after sensing number of photons[13]. This kind of noise is a type of electronic noise which occurs in an image due to small number of particles that carry energy[14]. This noise was added to the MRI images. Poisson distribution generally satisfies in many images which are having Poisson noise and also come across normally distributed and additive noise. Example radiography images and MRI images. Depending on the image intensity the magnitude of Poisson noise varies across an image which makes hard to remove the noise. All three filters Gaussian filter, Weiner filter, Median filter to remove Poisson Noise. The minimum size value after the filtration of the image was a contradiction between Gaussian and Median filter but the best clarity was achieved by Median filter with our experiment.

Salt Pepper Noise

Fifth Noise is the Salt and Pepper Noise which is added to all the MRI images and the filtered applied on these images is Weiner Filter,



(a) (a)

Fig. 6: (a)Gaussian Noise (b) De-Noised Image

IMAGES	Poisson Noise				
	WEINER FILTER	MEDIAN FILTER	GAUSSIAN FILTER	MINIMUM VALUE	CLARITY
MRI1	14197	10202	10177	gaussian filter	Median filter
MRI2	13373	9035	9488	median filter	Median filter
MRI3	13281	8952	9398	median filter	Median filter
MRI4	13245	9005	9356	gaussian filter	Median filter
MRI5	12769	8171	7701	gaussian filter	Median filter
MRI6	12765	8087	7501	gaussian filter	Median filter
MRI7	12714	7924	7213	gaussian filter	Median filter
MRI8	12583	7756	6896	gaussian filter	Median filter
MRI9	12287	7419	6433	gaussian filter	Median filter
MRI10	12288	7402	6310	gaussian filter	Median filter
MRI11	12204	7099	5931	gaussian filter	Median filter
MRI12	14088	10068	10051	gaussian filter	Median filter
MRI13	12063	6808	5440	gaussian filter	Median filter
MRI14	13773	9748	9671	gaussian filter	Median filter
MRI15	13571	9388	9293	gaussian filter	Median filter
MRI16	13472	9131	9180	median filter	Median filter
MRI17	13357	9090	9075	median filter	Median filter
MRI18	13491	9138	9452	median filter	Median filter
MRI19	13121	8783	9219	median filter	Median filter
MRI20	13337	8816	9227	median filter	Median filter

Fig. 7: Poisson Filtered Image size given by three filters

Median Filter, and Gaussian Filter. Acoustic noise which occurs due to the external channels and environment which affectsthe communication system, breakdown of image possession devices and sensor mistakes. Black and white dots which are usually seen in an image is due to this kind of digital images known as Salt-and-Pepper noise. The Median filter is used commonly to remove this kind of noise. In the experiment the used three filters were Weiner filter, Gaussian filter, Median filter[15] and the best result is observed by the median filter and the minimal size of an image was also noted by the same filter. This kind of noised images posses high density of Salt & Pepper noise in the digital images which is removed using Super-Mean Filter (SUMF). The working of this filter are generally in two stages, first stage is the detection of the noise in the image and the second stage is the replacement of noisy pixel with the mean value of the neighborhood noise free pixel in an image[16].

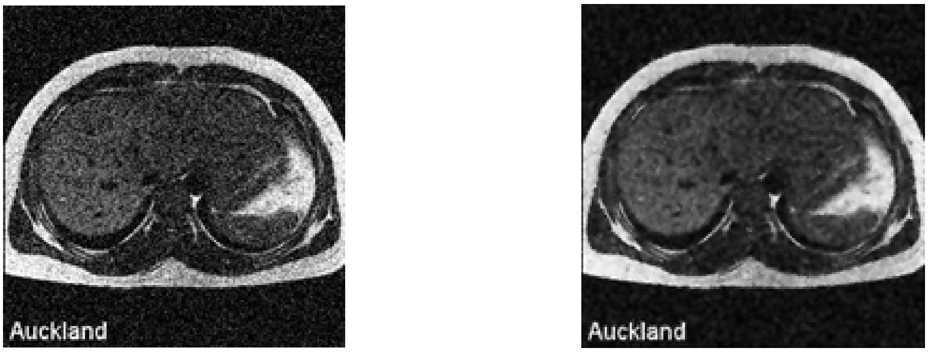
(a)

(b)

Fig.8: (a)Poisson Noise (b) Filtered Poisson MRI image

Images	salt and pepper Noise				
	WEINER FILTER	MEDIAN FILTER	GAUSSIAN FILTER	MINIMUM VALUE	CLARITY
MRI1	57214	28251	50935	median filter	median filter
MRI2	47271	32781	47309	median filter	median filter
MRI3	38475	30566	47875	median filter	median filter
MRI4	42816	21832	37467	median filter	median filter
MRI5	41376	22470	44712	median filter	median filter
MRI6	44327	17592	49974	median filter	median filter
MRI7	57141	21247	50082	median filter	median filter
MRI8	45464	37380	49162	median filter	median filter
MRI9	38535	22350	32400	median filter	median filter
MRI10	57984	27574	51580	median filter	median filter
MRI11	41682	16931	44558	median filter	median filter
MRI12	58845	24171	51007	median filter	median filter
MRI13	53306	20167	47602	median filter	median filter
MRI14	44376	25631	40361	median filter	median filter
MRI15	46372	33654	46460	median filter	median filter
MRI16	47547	26684	50345	median filter	median filter
MRI17	34618	16423	24694	median filter	median filter
MRI18	38727	19406	45411	median filter	median filter
MRI19	52287	28107	45253	median filter	median filter
MRI20	49718	30926	48900	median filter	median filter

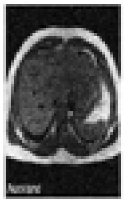
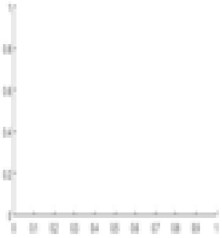
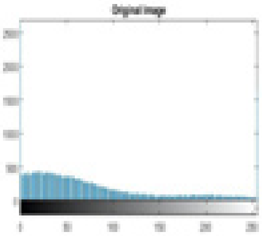
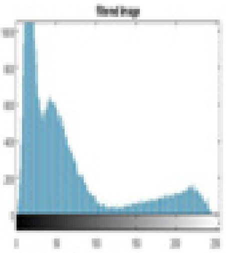
Fig. 9: Salt-and-pepper Filtered Image size given by three filters



(a) (b)

Fig. 10: (a) Salt pepper (b) Filtered salt pepper image

Table of MRI Single Image with their histogram

Noise	Histogram of Noisy Image	Histogram of filtered Image
Speckle Noise		
		

CONCLUSION

In this work we have taken twenty different medical images like MRI for doing our experiment for noise removal. We have added salt pepper, Gaussian, speckle, blurred and poison noise to the images and also removed these noises from the above medical images by applying the various filtering processes like Median, Gaussian and Weiner Filtering techniques.In order to achieve accurate results for the given application it is mandatory to get good and clear images. The results are examined and compared with ordinary pattern of noises; these are examined through the quality pixels, size, clarity and histogram of these images. From this experiment we come to conclusion that the selection of filters for removing the noise from medical images relies on the type of noise which is present in the image and filtering technique which will be used. From the obtained result, on an average base of histogram, image size and clarity of the taken medical images Median filter gives best results for Poisson and Salt and Pepper noise. Weiner filter gives best results than all other filters for Gaussian and Speckle Noise. Gaussian filter give best results for Gaussian Noise images. Comparative results of all filters used for the noise are shown among all filtering methods based on image size, clarity and histogram.The achieved results are more valuable and they establish to be useful forcommon to analyze which noised image can be de-noised using best filtering algorithm.

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12. Noise Through Removal of High Density Salt &Pepper Noise Through Removal of High Density Salt & Pepper Noise Through Super Mean Filter for Natural Images. Shyam Lal1, Sanjeev Kumar 2 and Mahesh Chandra3 1ECE Department, Moradabad Institute of Technology, Moradabad-244001(UP), India 2,3, ECE Department, Birla Institute of Technology,Mesra,Ranchi-835215(JH),India.
13. A Comparative Study of Various Types of Image Noise and Efficient Noise Removal Techniques Mr. Rohit Verma Dr. Jahid Ali School of Information Technology SSCIMT, Badhani, Pathankot, APJIMTC, Jalandhar, India India
14. Image De-noising by Various Filters for Different Noise Pawan Patidar Research Scholar (M. Tech.), Computer Science Department, Poornima College of Engineering, Jaipur, India, Sumit Srivastava Associate Professor,

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15. Study of Noise Detection and Noise Removal Techniques in Medical Images 1 Bhausaheb Shinde Head, Department of Computer Science, R.B.N.B. College, Shrirampur. Affiliated to Pune University Maharashtra, India Shinde.bhausaheb@gmail.com 2 Dnyandeo Mhaske Principal, R.B.N.B. College, Shrirampur. Affiliated to Pune University Maharashtra, India 3 A.R. Dani Head, International Institute of Information Technology, Hinjwadi, Pune Maharashtra, India.

16. A Comparative Analysis of Filters on Brain MRI Images Neha Jain*, D S Karaulia Department of Computer Engineering and Application National Institute of Technical Teachers Training and Research Bhopal, India.