Volume 10, Issue 3
June 2021

ITEE Journal
Information Technology & Electrical Engineering

ISSN: - 2306-708X

Performance Evaluation of Various Filter Techniques for De-noising Magnetic Resonance Imaging and Computed Tomography Images

[1]Dr.Aziz Makandar, [2] Miss. Rekha Biradar

[1]Department of Computer Science, KSAWU Vijayapura, Karnataka, India

[2]Department of Computer Science, KSAWU Vijayapura, Karnataka, India

E-mail: [1]azizmakandar@kswu.ac.in, [2]rekb92@gmail.com

ABSTRACT

The current state of medical science is highly dependent on medical images and the Magnetic Resonance Imaging (MRI), Computed Tomography (CT), and other medical imaging techniques are examples. Doctors use these medical images to analyze body structures and prepare for treatments. However, medical images are typically complex and noisy. Image de-noising has the potential to be a vital problem in the field of medical imaging. It has been demonstrated in this paper that different types of noise have an impact on image quality and image information. Noise is emitted during the acquisition, propagation, reception, storage, and retrieval phases. Consequently, image de-noising becomes a crucial task for defect correction. In this study, compares the output of five alternative filters for MRI and CT images using the Average filter, Wiener filter, Gaussian filter, Median filter, and Order Statistics Filter. For performance evaluation, the SNR, PSNR, and MSE are used to compare the filters. Based on the parameters, the filter that is most successful in eliminating the corresponding noise is determined.

Keywords: *De-Noise Noise Models, Filter Techniques Parameters, MRI, CT, Salt and Pepper, Gaussian, Speckle, Poisson, Median, Average, Order Statistics, Wiener.*

1. INTRODUCTION

Noise is considered as a signal that interferes with the original image information and lowers the visible quality of a digital image. The primary sources of noise in digital photographs include incomplete equipment, the picture acquisition method while sending and compaction, environmental requirements during picture collecting, insufficient light-weight levels, and system temperature, all of which impact the imaging device's durability [1]. Rapid advances in information technology (IT) and medical devices have benefited in the evolution of digital medical imaging.

Over the last thirty years, rapid improvements in information technology and clinical instruments have aided in the development of standardised clinical imaging. X-ray, CT, mammography, atomic medical imaging together with Single Photon Emission Computed Tomography (SPECT), distinct computerized radiological cycles of vascular, cardiovascular, and contrast imaging, and Positron Emission Tomography (PET) are essential for this flip of activities [4].

Medical images are used by the doctors for various purposes, including anatomical feature examination, treatment planning, distinguishing tissues and glands, and volume measurements is increasing rapidly. Usually, the medical field uses imaging technologies such as MRI, CT, and Ultrasound scans; others produce health-related images. Medical images, on the other hand, are usually complex and noisy [7].

This paper discusses five standard filters. The restoration process involves generating degradation and retrieving the same image using the inverse operation. As appear in Figure.1, we suggest restoring a noisy image R as defined by R = O + N [3].

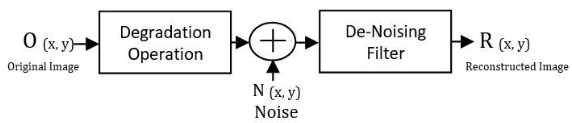


Figure1: Basic model of image restoration

O- Original image.
N- Additive noise.
R- Reconstructed image.

It is crucial to maintain the feature of an image's by lowering the amount of noise. It describes the different types of noises that can be seen in MRI and CT images and the filters used to remove those noises [5]. Digital images are used in several applications, including medical imaging, satellite television, MRI, CT, and scientific and technological fields such as geographic information systems [6].

There is a possibility of real-time noise. It is primarily based on adding various kinds of noise relying on the real-time scenario. The results of noise may additionally be additive and multiplicative. Gaussian noise, Salt and Pepper noise, and random noise are whole varieties of additive noise. Speckle noise is an example for multiplicative noise. A greyscale or colour picture was captured for processing. If the input image is in colour, it is transformed to greyscale [1].

Volume 10, Issue 3
June 2021

ITEE Journal
Information Technology & Electrical Engineering

ISSN: - 2306-708X

1.1 NOISE MODELS

In image processing, denoising is a big concern. Noise degrades and obstructs the image's consistency. The first step in image enhancement is denoising [16]. Image restoration attempts to eliminate noise from an image and return it to its original quality. This is a critical aspect of preserving image quality when restoring pixel value. [14]. The presence of noise in an image may be additive or multiplicative.

O (x, y)- original image.
n (x, y) - noise.
R (x, y)- distorted image.
(x, y)- pixel position [6].
additive noise follows the norm

$$R(x,y) = O(x,y) + n(x,y) \qquad (1)$$

while multiplicative noise

$$R(x,y) = O(x,y) * n(x,y) \qquad (2)$$

Depicting a progression of noise models utilizing probability density functions. Poisson, Salt and Pepper, Gaussian, and Spackle are the most widely recognized noises in medical images shows in figure 2. These noises are examined at a stretch below [2].

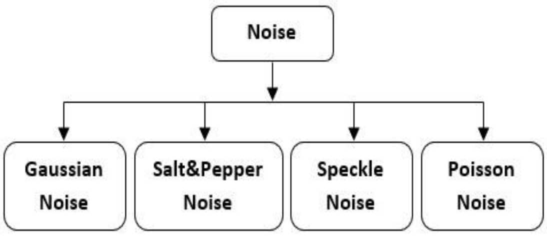


Figure2: Types of noises that were added to the image.

- **Gaussian Noise (Standard Noise):**

  The size of Gaussian noise is unaffected by the signal intensity at each pixel. To modify the value of each pixel from its original value, a tiny number will be utilised [11].Smoothing image pixels removes acquisition noise, although the effect might be unpleasant sometimes, resulting in blurry edges in elevated images [14]. Gaussian Noise equation as follows.

$$P(z) = \frac{1}{\sqrt{2\pi\sigma}} e^{\frac{-(z-u)^2}{2\sigma^2}} \qquad (3)$$

  μ and σ represents mean and standard deviation, respectively.

- **Salt and Pepper Noise:**

  Impulse noise, independent noise, and spike noise are all terms used to describe salt and pepper noise. Impulse noise is caused by fast transitions, such as defective switching. Malfunctioning pixels, analog-to-digital conversion issues, and transmission bit errors are some of the causes. There may be considerably reduced using the dark frame subtraction technique and interpolating over dark/bright pixels [19].

$$P(Z) = \begin{cases} P_a & for\ z = a \\ P_b & for\ z = b \\ 0 & otherwise \end{cases} \qquad (4)$$

  1) If either P_a or P_b is zero, then it is called as unipolar noise.
  2) If neither Pa nor Pb is zero or if that are approximately equal then it is referred to as Salt and Pepper noise.
  3) If a is 0 it indicates black and if b is 255 it indicates white [5].

- **Speckle Noise:**

  Speckle noise is an example for Multiplicative noise. Similarly, as phasors with random amplitude and introduce free house are viewed as an infinite add of independents, speckle noise is perceived as an endless add of independents [11]. Speckle noise occurs in different forms. This specifically refers to the fact that speckle noise's variance is comparable to the conflict of the feature.

$$F(g) = \frac{g^{\alpha-1}}{(\alpha-1)!a^{\alpha}} e^{\frac{-x}{\alpha}} \qquad (5)$$

  Where:
  α -represents variance.
  g - represents grey value.

- **Poisson noise:**

  Instead of obtaining an external effect, it is created from the data of the original image [11]. Shot noise is also known as Poisson noise. Due to the statistical existence of electromagnetic waves, it becomes apparent in the image [5]. This form of noise occurs when the numbers of photons detected by the sensors are insufficient to detect statistical variations in measurement. The critical cause of Poisson noise is photon fluctuations [18].

1.2 FILTER TECHNIQUES

As a result, noises are detected using nearby information and are filtered by using the finest filtering methods, which will not be affecting the image quality, hence reinforcing the smoothness of the image was captured for the analysis.

Average Filter:

The addition of total values inside the filter window is used to substitute the pixel. Instead of removing the speckle from the image, it is blended into one. In the filter window, dark and light speckle pixels will theoretically balance out each other. The probability of such events increases as the filter window size grows. However, it causes image distortion, information loss, and, finally, spatial resolution loss [20]. It computes the distorted image g (s, t) average value in the $S_{x,\ y}$ field. At any position (x, y), the reconstructed image f (x, y) value is

$$f(x,y) = \frac{1}{mn} \sum_{(s,t)\epsilon S_{x,y}} g(s,t) \qquad (6)$$

Gaussian Filter:

A Gaussian filter is used to remove high-frequency components from an image. As a result, it has the capability of being used as a low pass filter [8]. A Gaussian filter mathematically modifies the input image by convolution with a Gaussian function. A two-dimensional convolution operator that blurs images while removing information and noise is the Gaussian smoothing operator [15].

$$F(g) = \frac{1}{\sqrt{2\pi\sigma^2}e^{-(g-m)^2/2\sigma^2}} \quad (7)$$

Where:

g–grey value.

m –average function, and

σ- noise's standard deviation [3].

Median Filter:

The median value of neighbouring pixel is used by the Median filter to replace the pixel values instead of using the mean. The median is calculated by numerically ranking all the image pixels in the neighbouring regions and afterwards substituting the pixels with the median pixel values[21]. While this filter removes noise, it compromises adequate information. Researchers use median filters because they can successfully reduce noise with less blurring for a wide range of noise types. In addition to image processing, signal processing, and time-series processing, median filters are frequently employed as smoothers [12].

$$f(x,y) = median_{(s,t)\in S_{xy}}\{g(s,t)\} \quad (8)$$

Order Statistics Filter:

The rank, median, minimum, and maximum sort are computed using the nearest neighbour's pixel in order of increasing depending upon on grey - level values in an Order filters, and this sorting would be used to locate the optimal value or position. The ranking is referred as values or position in this order list [7]. The n pixels should be arranged numerically (S1, S2, S3, ...Sn),

Where S1 ≤ S2 ≤ ……Sn output is then chosen, with

$$Rank(k) = Sk1 \leq k \leq n \quad (9)$$

When completed this for all possible window locations,

$$G = Rk(S) \quad (10)$$

Where:

S- input image.

G- it defines the refined image.

k-it defines position with rank.

Wiener Filter:

The images are degraded using additive noise and blurring, and the MSE-optimal statistic linear filter becomes the Wiener filter. The Wiener filter must be obtained by assuming that the signal or noise approaches are both second-order statistics. [21].

$$G(u,v) = \frac{H*(u,v)Ps(u,v)}{|H(u,v)|2Ps(u,v)+Pn(u,v)} \quad (11)$$

Where:

Degradation feature H(u, v)

H*(u, v) is Degradation function of complex conjugate.

Pn (u, v) is Noise Power Spectral Density.

Ps (u, v) is Image's unaltered Power Spectral Density.

1.3 Performance Measurement Parameters

Signal and Noise Ratios:

The signal and noise ratio (SNR) is calculated by multiplying the volume of noise by its standard deviation (n) [10].

$$SNR = 10\log_{10}\frac{\frac{1}{M*N}+\sum_{m=0}^{M-1}\sum_{n=0}^{N-1}f(m,n)^2}{\frac{1}{M*N}+\sum_{m=0}^{M-1}\sum_{n=0}^{N-1}(f(m,n)-g(m,n))^2} \quad (12)$$

f(m, n) - original image

g(m, n) - restored image.

Mean Square Error (MSE):

MSE stands for the cumulative square error between the planar image and the original image. The reconstructed and original images are exhibited in comparison. It's used to figure out how much the original and reconstructed images vary [17].

$$MSE = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}[y(i,j)-x(i,j)]^2 \quad (13)$$

Peak Signal Noise Ratio (PSNR):

The PSNR value represents the accurate value of the image being reconstructed. The PSNR is used to calculate the image loss' efficacy. PSNR distinguishes the relationships between the original image, noise, and decoded image [17].

$$PSNR = 10\log_{10}\left(\frac{255^2}{MSE}\right) \quad (14)$$

2. RELATED WORK

Janaki K et al. [1] In this study, Different forms of noise affect image quality and details in images. Different kinds of filters might also be used to restore the visual quality and data from the noisy image. This paper considers Gaussian noise, Speckle noise, and random noise, and Salt and Pepper noise, which can be reduced using Gaussian filters, Average filters, Median filters, or Adaptive Median filters. Four distinct filters are examined for a greyscale cameraman image, and it is discovered that the adaptive median filter surpasses the improved de-noising technique in image processing.

Prashant Dwivedy et al. [2] In this study author goes through all the different types of noise that can degrade an image. The test has been done on Lena greyscale image. The elimination of various noises from images has been achieved with several types of filters. A variety of measurement parameters are used to compute the filter that is incredibly advantageous in removing a certain noise. And it was determined that the Mid-Point filter is good for Poisson, Multiplicative, and Gaussian noise. Rayleigh prefers the Arithmetic Mean filter. The Median filter works well for Exponential, Salt and Pepper. The Geometric Mean filter is an excellent filter for Erlang, Uniform noise.

Azadeh Noori Hoshyar et al. [3] Author of this paper has covered five different filtering methods and four different types of noises applied to skin cancer images with intensities ranging from 10% to 80% for medical applications. The aim is to compare filters by measuring PSNR to find out how they behave in the presence of various types of noise. Adaptive Wiener, Adaptive Median Filter works well for Salt & Pepper noise, and with high Speckle intensities, in Gaussian, Poisson,

ITEE Journal
Information Technology & Electrical Engineering

ISSN: - 2306-708X

or low Speckle intensities, mean filters offer superior outcomes. This work aims to inspire researchers to select superior strategies for pre-processing their skin cancer detection system to achieve the best possible results.

Manoj Gupta et al. [5] The author presents, the various filters to reduce the noise in an ultrasound image and evaluating the output with PSNR, MSE, and RMSE, so that the image quality can be increased. Since a greater PSNR value corresponds to a greater filtering value, An image of high quality must have the smallest possible MSE and RMSE values because the error must be low. The PSNR, MSE, and RMSE numerical figures show that the filters have outstanding characteristics and edge preservation efficiency, allowing for more Ultrasound Image De-noising for diagnosis and therapy. Furthermore, the Mean Filter effectively removes Speckle, Salt or Pepper Noise, and Poisson Noise, and the Gaussian Filter effectively removes Gaussian Noise is concluded in this work.

ZinatAfrose et al. [22] In this study, tried to remove the Salt & Pepper, Gaussian, and Speckle noises from complex images using the Median filter, Relaxed median filter, Wiener filter, Center-weighted median filter, and Averaging filter. In order to analyse and evaluate various filter outputs with applied noise, complex images are used to extract the PSNR value. According to the overall performance and test outcomes, the relaxed median filter produces higher outcomes for compound images.

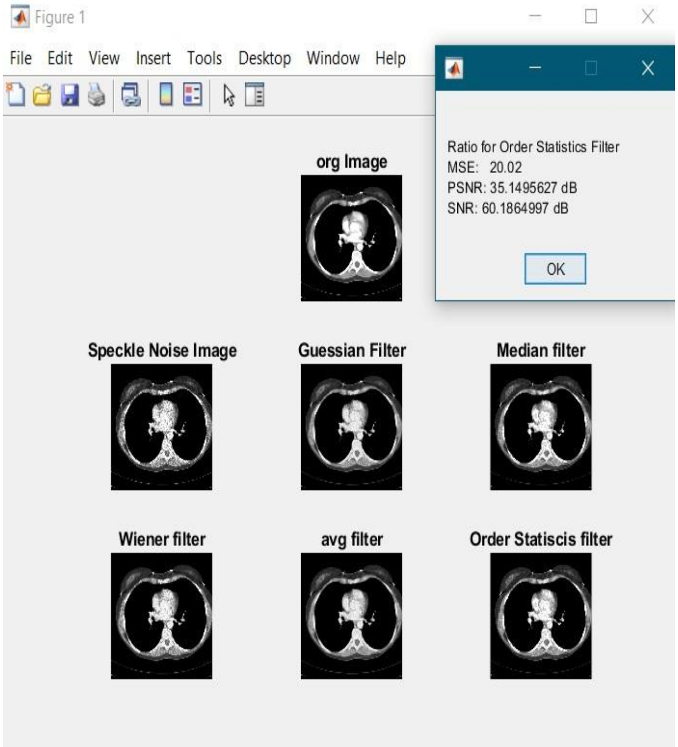
Shivani Sharma et al. [19] This study examines the output of different filters used to remove impulse noise from images. The MSE and PSNR are the output standards. According to the findings, the median filter provides the most effective noise reduction for salt and pepper.

3. MATERIALS AND METHODS

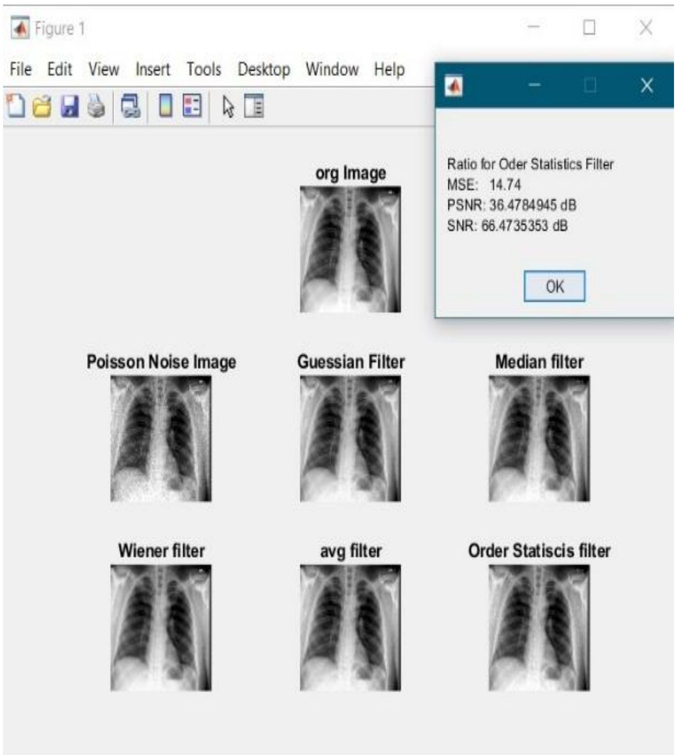
Paper presents an MRI and CT image denoising approach based on Gaussian filter, Median filter, Wiener filtering, Average filter and, Order statistic filter. The original values are comprehensive collection of series of MRI Chest Images obtained from the Open datasets and CT images obtained from the Kaggle database for the study, whereas 20 MRI and CT images of each have been used for testing. They are free of noise and have a high resolution. MRI & CT images are chosen for testing with MATLAB R2020b since this analysis focuses on filtering algorithms.

3.1 RESULTS AND DISCUSSION

An MRI and CT scan with a resolution of 512 × 512 pixels were used as a test image, and various noises were applied to the input image which is known as noisy image (see Figure.3). The noisy image is then subjected to a series of filters in order to create a comprehensible and de-noised image. The de-noised image can now be used to determine error metrics. The Error Calculator is used to determine SNR, PSNR, and MSE (Error: difference between original image and restored image). Figure.3and 4 shows the result and the process of our proposed method are illustrated, and the algorithm is shown below.



(a)



(b)

Figure 3: (a) added Spackle noise and used various filters to De-noise CT image; (b) added Poisson noise and used various filters to De-noise MRI image;

ITEE Journal
Information Technology & Electrical Engineering

ISSN: - 2306-708X

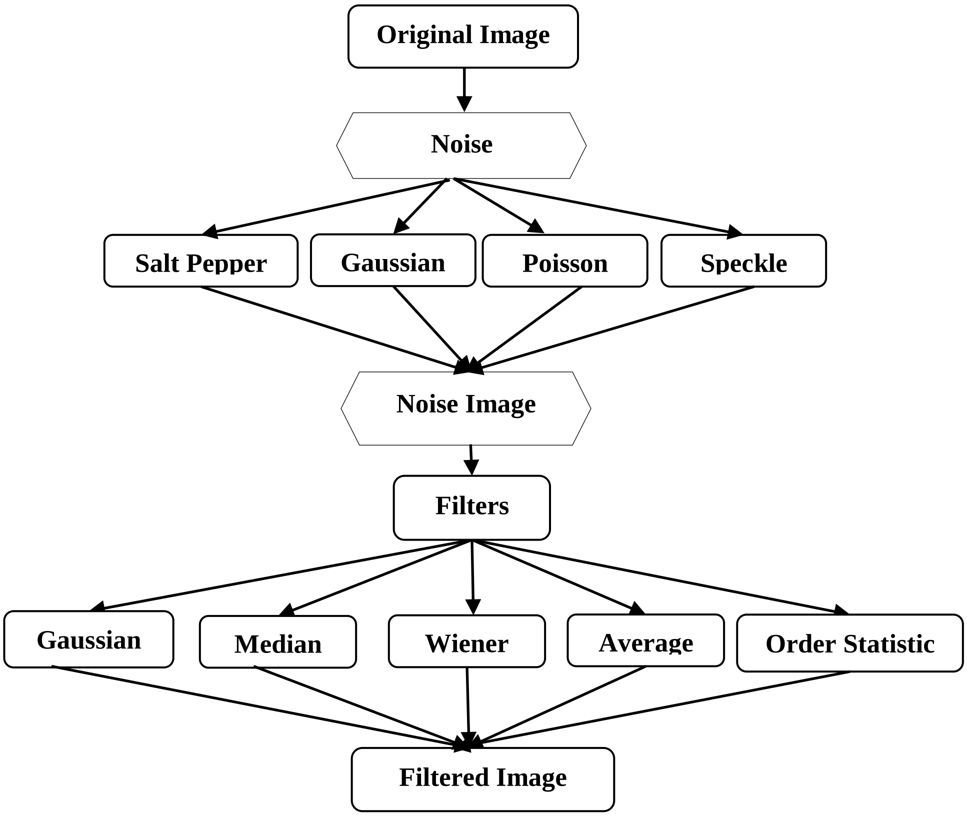
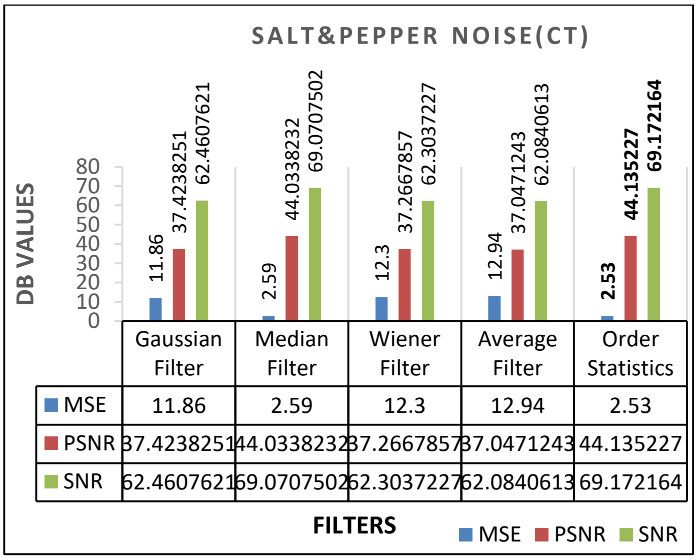


Figure 4: Process of proposed method

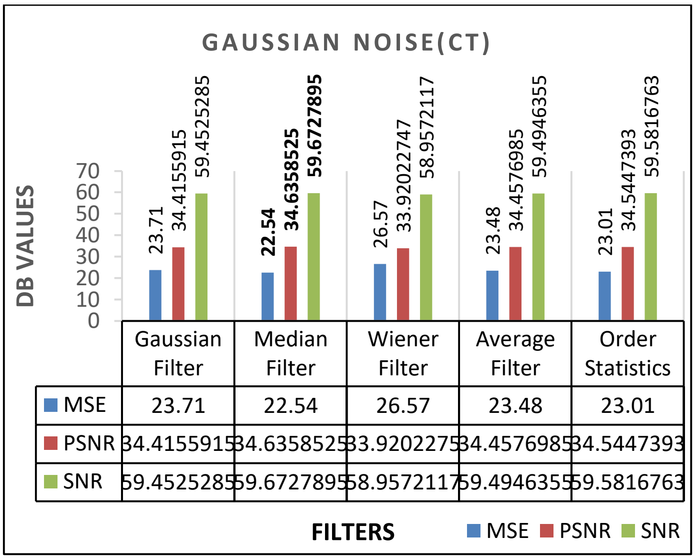
Flow of the Program:

1. Acquire original image.
2. Resize the original image.
3. Add an amount of noise to resized image.
4. The different types of filters are used to de-noise images that have been distorted by various types of noises (Average, Gaussian, Order Statistics, Median, and Wiener).
5. Subplot the image (original, noisy, and filtered images) to get a multi-image in one single frame: (3, 3, 1) ……. (3,3,9); Displays the input image alongside the filtered images;
6. After applying the filter, assess the image quality using various parameters (like PSNR, SNR, and MSE).

All five filters are applied in series, and parameters are differentiated for each noise, namely shown in the tables and charts below.



	Gaussian Filter	Median Filter	Wiener Filter	Average Filter	Order Statistics
MSE	11.86	2.59	12.3	12.94	2.53
PSNR	37.4238251	44.0338232	37.2667857	37.0471243	44.135227
SNR	62.4607621	69.0707502	62.3037227	62.0840613	69.172164

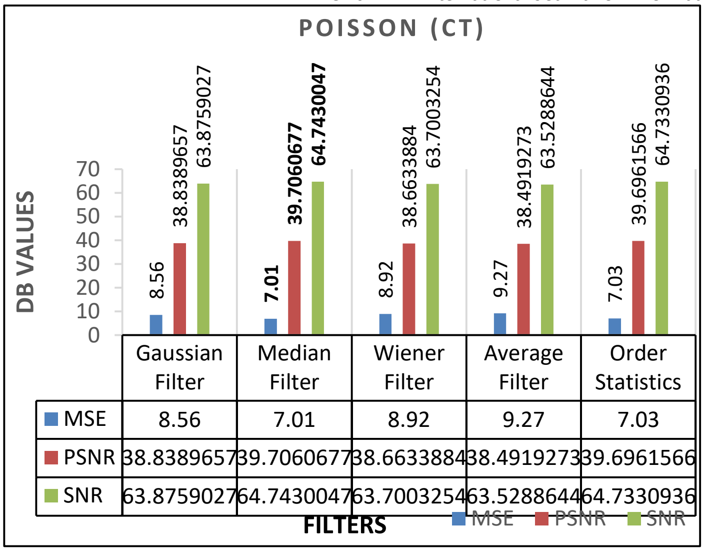


	Gaussian Filter	Median Filter	Wiener Filter	Average Filter	Order Statistics
MSE	23.71	22.54	26.57	23.48	23.01
PSNR	34.4155915	34.6358525	33.92022747	34.4576985	34.5447393
SNR	59.4525285	59.6727895	58.9572117	59.4946355	59.5816763

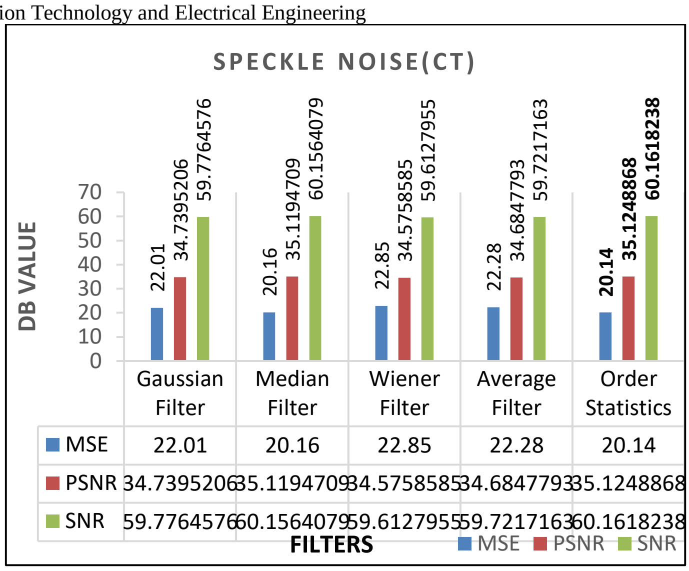
Volume 10, Issue 3
June 2021

ITEE Journal
Information Technology & Electrical Engineering

ISSN: - 2306-708X

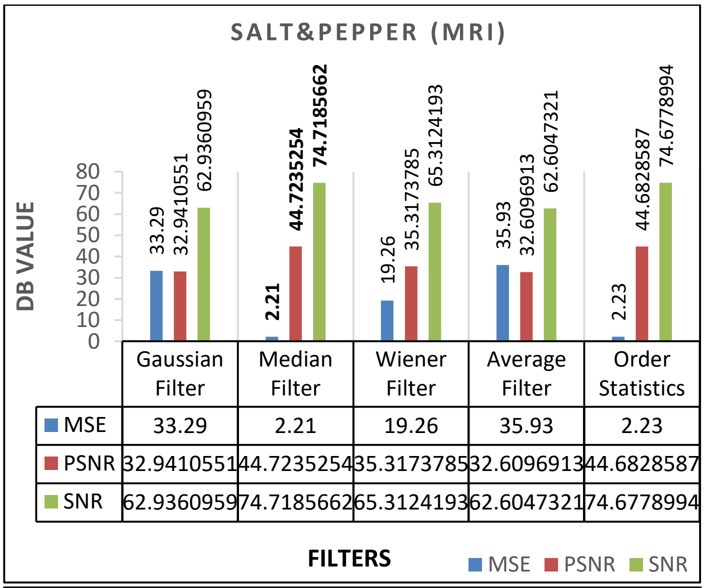


	Gaussian Filter	Median Filter	Wiener Filter	Average Filter	Order Statistics
MSE	8.56	7.01	8.92	9.27	7.03
PSNR	38.8389657	39.7060677	38.6633884	38.4919273	39.6961566
SNR	63.8759027	64.7430047	63.7003254	63.5288644	64.7330936

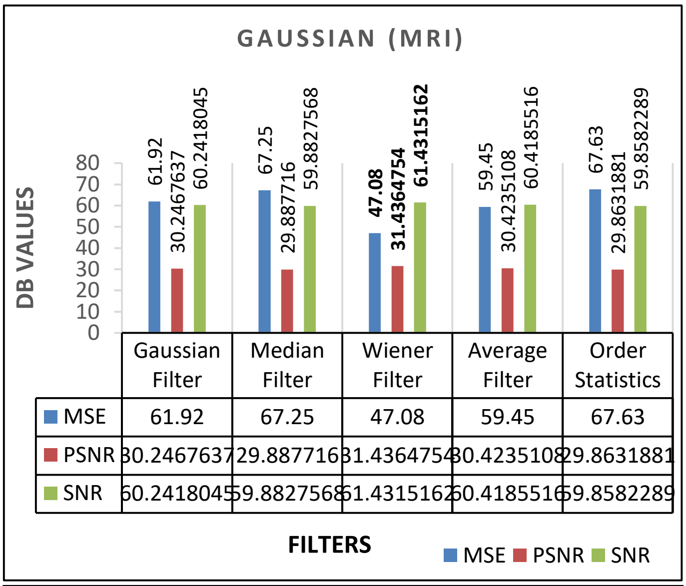


	Gaussian Filter	Median Filter	Wiener Filter	Average Filter	Order Statistics
MSE	22.01	20.16	22.85	22.28	20.14
PSNR	34.7395206	35.1194709	34.5758585	34.6847793	35.1248868
SNR	59.7764576	60.1564079	59.6127955	59.7217163	60.1618238

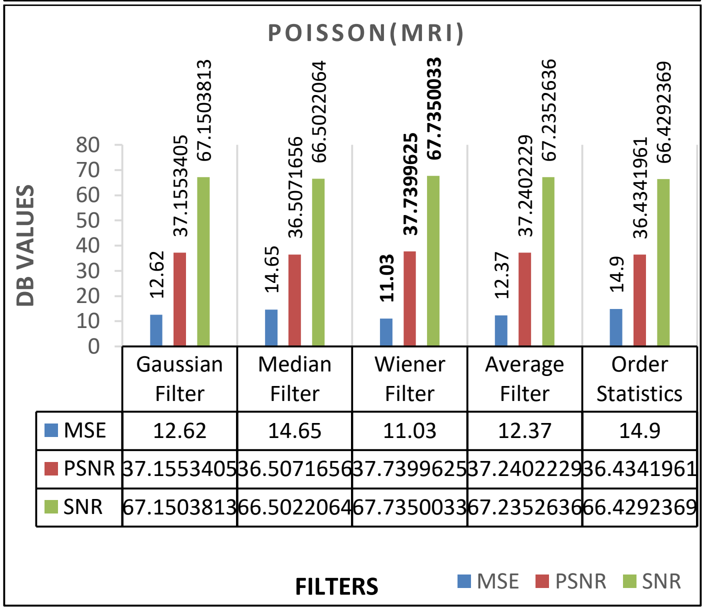
Chart -1: Resultant graph of filter parameters for a variety of noise introduced to the CT image



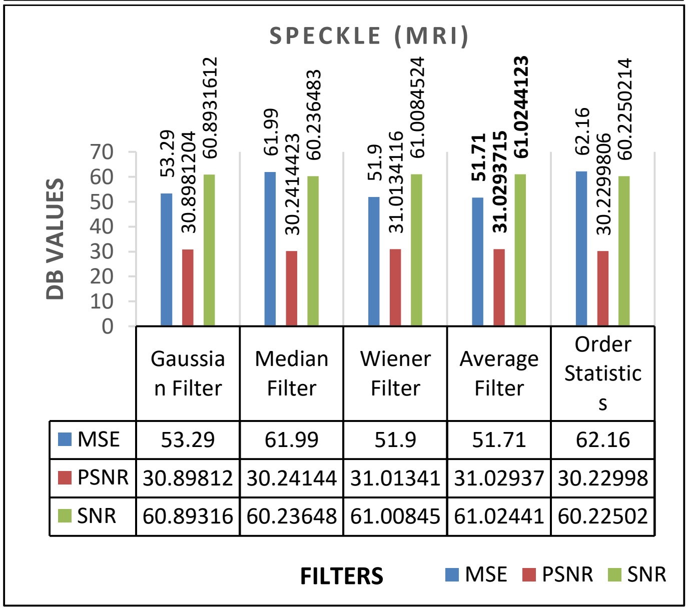
	Gaussian Filter	Median Filter	Wiener Filter	Average Filter	Order Statistics
MSE	33.29	2.21	19.26	35.93	2.23
PSNR	32.9410551	44.7235254	35.3173785	32.6096913	44.6828587
SNR	62.9360959	74.7185662	65.3124193	62.6047321	74.6778994



	Gaussian Filter	Median Filter	Wiener Filter	Average Filter	Order Statistics
MSE	61.92	67.25	47.08	59.45	67.63
PSNR	30.2467637	29.887716	31.4364754	30.4235108	29.8631881
SNR	60.2418045	59.8827568	61.4315162	60.4185516	59.8582289



	Gaussian Filter	Median Filter	Wiener Filter	Average Filter	Order Statistics
MSE	12.62	14.65	11.03	12.37	14.9
PSNR	37.1553405	36.5071656	37.7399625	37.2402229	36.4341961
SNR	67.1503813	66.5022064	67.7350033	67.2352636	66.4292369



	Gaussian Filter	Median Filter	Wiener Filter	Average Filter	Order Statistics
MSE	53.29	61.99	51.9	51.71	62.16
PSNR	30.89812	30.24144	31.01341	31.02937	30.22998
SNR	60.89316	60.23648	61.00845	61.02441	60.22502

Chart -2: Resultant graph of filter parameters for a variety of noise introduced to the MRI image.

Volume 10, Issue 3
June 2021

ITEE Journal
Information Technology & Electrical Engineering

ISSN: - 2306-708X

Table 1: Comparison table of filter parameters for various noises added to the CT image.

Noises\Filters	Gaussian Filter			Median Filter			Wiener			Average Filter			Order Statistics Filter		
	MSE	PSNR	SNR	MSE	PSNR	SNR	MSE	PSNR	SNR	MSE	PSNR	SNR	MSE	PSNR	SNR
Salt&Pepper	11.86	37.42383	62.46076	2.59	44.03382	69.07075	12.3	37.26679	62.30372	12.94	37.04712	62.08406	**2.53**	**44.13523**	**69.17216**
Gaussian	23.71	34.41559	59.45253	**22.54**	**34.63585**	**59.67279**	26.57	33.92023	58.95721	23.48	34.4577	59.49464	23.01	34.54474	59.58168
Poisson	8.56	38.83897	63.8759	**7.01**	**39.70607**	**64.743**	8.92	38.66339	63.70033	9.27	38.49193	63.52886	7.03	39.69616	64.73309
Speckle	22.01	34.73952	59.77646	**20.16**	**35.11947**	**60.15641**	22.85	34.57586	59.6128	22.28	34.68478	59.72172	20.14	35.12489	60.16182

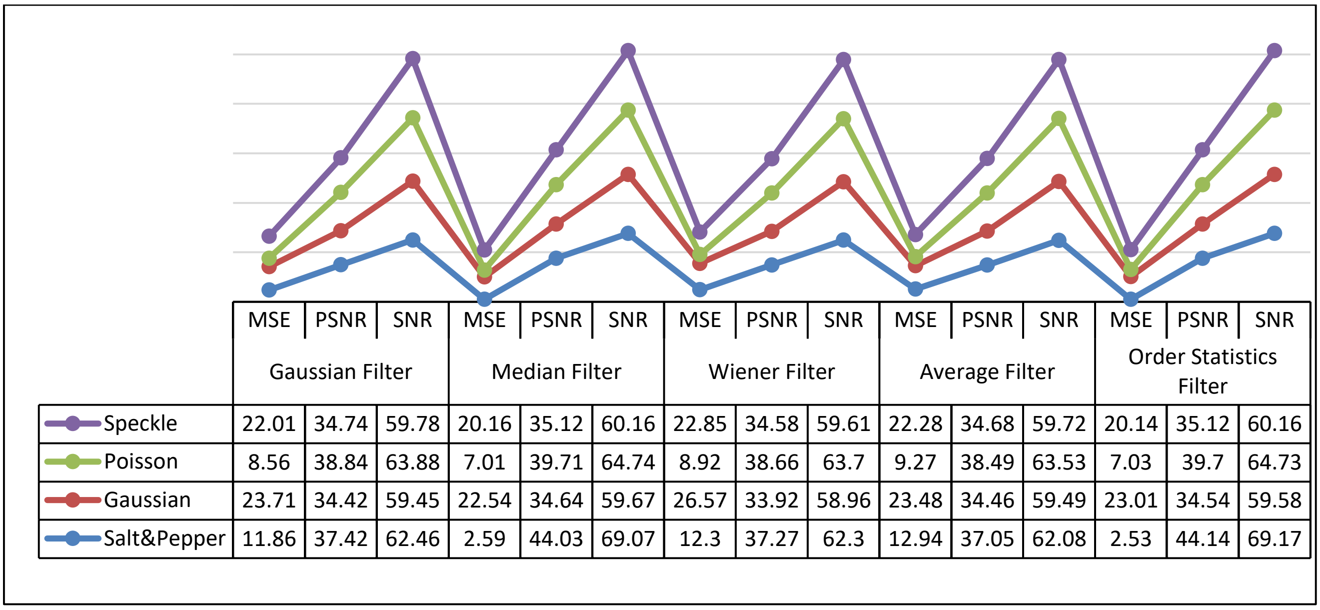


Chart 3: Comparison chart of filter parameters for various noises added to the CT image

Table 2: Elapsed time for denoising MRI and CT images using different filters.

Filters\Noise	Salt & Pepper Noise		Gaussian Noise		Poisson Noise		Speckle Noise	
	CT	MRI	CT	MRI	CT	MRI	CT	MRI
Gaussian Filter	0.175918	0.166305	0.186	0.163182	0.225607	0.196931	0.1595	0.162491
Median Filter	0.166821	0.163788	0.19729	0.163141	0.213659	0.210827	0.163602	0.16803
Wiener Filter	0.184152	0.168283	0.184263	0.170613	0.216728	0.218265	0.176055	0.164072
Average Filter	0.163733	0.161089	0.167168	0.164321	0.222942	0.215412	0.156179	0.156704
Order Statistics Filter	0.016877	0.016882	0.01868	0.018614	0.089994	0.082451	0.01758	0.020008

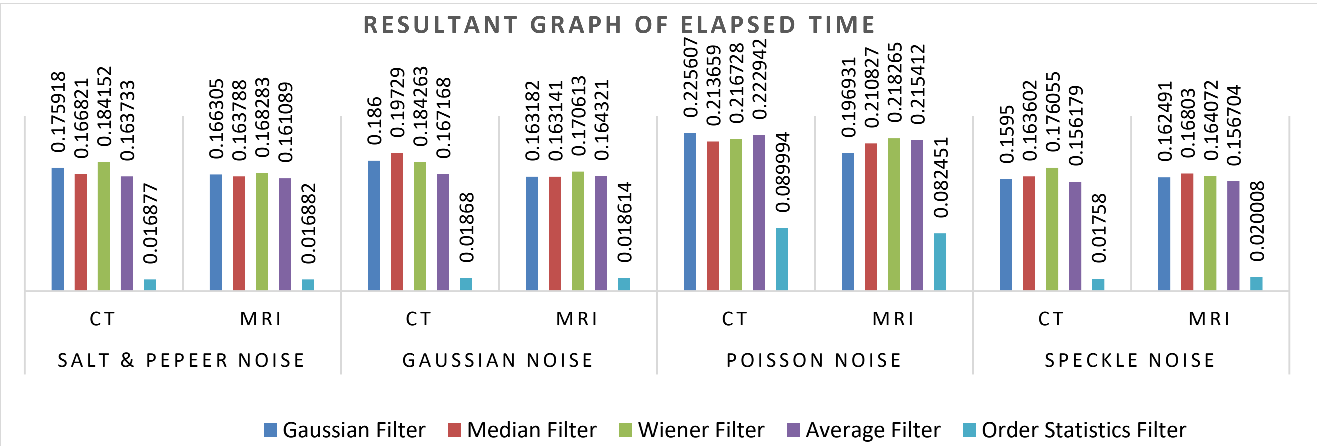


Chart -4: Elapsed time chart for denoising MRI and CT images using different filters.

As shown in Tables 1, 2, Charts 1 to 4, removing noise from an image has a number of benefits using a variety of filtering techniques, the parameter values are computed, and the time taken for the process is varies. The image filtered by various filters shows improved PSNR values as well as other characteristics when compared to the noisy image.

CONCLUSIONS

In the present study, four types of noises are applied to the MRI and CT medical images such as Poisson noise, Salt and Pepper, Gaussian, and Speckle noise. All noise reduces image quality, resulting in information loss, according to studies. Filters are used to assess image quality in this study. Based on the parameters shown in the above tables and charts, it is computed which filter will be the best one for eliminating respective noise. The conclusion table is shown in Table.3 below.

Table -3: Result of the proposed method

Noises	Filters	
	CT	MRI
Salt Pepper Noise	Median Filter	Median or Order statistics Filter
Gaussian Noise	Average Filter	Wiener Filter
Poisson Noise	Order Statistics Filter	Wiener Filter
Speckle Noise	Gaussian Filter	Average Filter

REFERENCES

[1] Janaki K, Dr. M. Madheswaran, “Performance Analysis of Different Filters with Various Noises in Pre-processing of Images”, 1st International Conference on Innovations in Computing & Networking (ICICN16), CSE, RRCE,(2016).

[2] Prashant Dwivedy, Anjali Potnis, Shahbaz Soofi, Pooja Giri, “Performance Comparison of Various Filters for Removing Different Image Noises”, Proceeding International conference on Recent Innovations is Signal Processing and EmbeddedSystems (RISE-2017) 27-29 (Springer),(2017).

[3] Azadeh Noori Hoshyar, Adel Al-Jumaily, Afsaneh Noori Hoshyar, “Comparing the Performance of Various Filters on Skin Cancer Images”, International Conference on Robot PRIDE 2013-2014 - Medical and Rehabilitation Robotics and Instrumentation, ConfPRIDE,(Elsevier), (2014).

[4] Dev. R. Newlin, C. Seldev Christopher, “Medical Image Denoising Using Different Techniques”, International Journal of Scientific &Technology Research Volume 9, Issue 03, Issn 2277-8616, March 2020

[5] Manoj Gupta a, Heena Taneja b, Laxmi Chand c, “Performance Enhancement and Analysis of Filters in Ultrasound Image Denoising”, International Conference on Computational Intelligence and Data Science (ICCIDS 2018) Procedia Computer Science 132 (2018) 643–652(Elsevier), (2018).

[6] Mahesh Mohan M R, “Medical Image Denoising Using Contourlet Transform, Bilateral and Nlm Filtering”, Department of Electronics and Communication Engineering Govt. Engineering College Trichur Thrissur, Kerala State, A Thesis, (July 2013)..

[7] Manoj kumar V, Remyaelizabeth Philip, Arun A, Sumithra M G, “Comparative Analysis of Different Filters for Denoising In Medical Image Segmentation”, International Journal of Innovative Research in Science, Engineering and Technology Vol. 2, Issue 3, March 2013.

[8] Ch. Rajasekhara Rao, M N V S S Kumar, G SasiBhushana Rao, “Investigation of Optimal Denoising Filter for MRI Images”, International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Number 15, (2018).

[9] Ahmed S. Bafaraj, “Performance Analysis of Best Speckle Filter for Noise Reduction in Ultrasound Medical Images”,International Journal of Applied Engineering Research ISSN 0973-4562 Volume 14, Number 6, (2019).

[10] A. Buades, B. Coll, and J. M. Morel, “A Review of Image Denoising Algorithms, With A New One”, Society for Industrial and Applied Mathematics. Vol. 4, No. 2, pp. 490–530, (2005).

[11] Arin H. Hamad, Hozheen O. Muhamad and Sardar P. Yaba, “De-noising of medical images by using some filters”, International Journal of Biotechnology Research Vol. 2(2), July 2014.

[12] Iza Sazanita Isa, Siti Noraini Sulaiman, Muzaimi Mustapha, SailudinDarus, “Evaluating Denoising Performances of Fundamental Filters for T2- Weighted MRI Images”, 19th International Conference on Knowledge Based and Intelligent Information and Engineering Systems, (2015).

[13] Yanqiu Zeng, Baocan Zhang, Wei Zhao, Shixiao Xiao, Guokai Zhang, Haiping Ren, Wenbing Zhao, Yonghong Peng, Yutian Xiao, Yiwen Lu, YongshuoZong, and Yimin Ding, “Magnetic Resonance Image Denoising Algorithm Based on Cartoon, Texture, and Residual Parts”, Hindawi Computational and Mathematical Methods in Medicine Volume 2020, Article ID 1405647, (2020).

[14] NalinKumar and Mrs. M Nachamai, “Noise Removal and Filtering Techniques used in Medical Images”, Oriental Journal of Computer Science & Technology, ISSN: 0974-6471, Vol. 10, No. (1): Pgs. 103-113, March 2017.

[15] Amira A. Mahmoud, S. EL Rabaie, Taha E. Taha, Osama Zahran and Fathi E. Abd El-Samie, W. Al-Nauimy, “Comparative Study between Different Denoising Filters for Speckle Noise Reduction in Ultrasonic BMode Images”, IEEE November 2012.

[16] Aziz Makandar, Rekha Biradar, Nayan Jadhav, “Convolutional Neural Network (CNN) applied for Image Enhancement process”, International Conference on Artificial Intelligence and Soft Computing, ISBN: 978-93-88929-53-0, (ICAISC-2021).

[17] Aziz Makandar, Rekha Biradar, “Analysis of 3D Medical Image Compression”, International Conference on Artificial Intelligence and Soft

Computing, ISBN:978-93-88929-53-0, (ICAISC-2021).

[18] Gursharan Kaur, Rakesh Kumar, KamaljeetKainth, "A Review Paper on Different Noise Types and Digital Image Processing", International Journal of Advanced Research in Computer Science and Software Engineering Volume 6, Issue 6, 2016.

[19] Shivani Sharma, Kamal Kumar. "Acomparison of Salt and Pepper Noise Removal Filters", International Journal of Engineering Science and Computing Volume 6, Issue 8, 2016.

[20] P. Kupidura, "Comparison of Filters dedicated to Speckle Suppression in SAR images", The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Science, Volume XLI-B7, 2016.

[21] Sheikh Tania, Raghad Rowaida, "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. Vol.9,pp.113-124, (2016).

[22] ZinatAfrose, "A Comparative Study on Noise Removal of Compound Images using Different Types of Filters", International Journal of Computer Applications, Volume 47-No.14, (2012).

[23] Aziz Ur Rahaman Makandar and K. karibasappa, "Wavelet Based Medical Image Compression Using SPHIT," Journal of Computer and Mathematical Sciences, Vol. 1, Issue 7, Dec 2010.

AUTHOR PROFILES

Dr. Aziz Makandar received the Ph.D. award in Computer Science and Engineering. Currently, he is a Professor at Karnataka State Akkamahadevi Women's University, Vijayapura. His area of research includes Image Processing.

Miss. Rekha Biradar received the degree in Masters in Computer Application from BLDEA's Engineering and Technology, in 2015. She is a research student of Karnataka State Akkamahadevi Women's University, Vijayapura.