

# Detection of Breast Cancer using MRI: A Pictorial Essay of the Image Processing Techniques

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**Abstract:** -Medical imaging generates the visual representation of the interior body parts for the clinical analysis/ medical intervention. Now a days, an advanced medical imaging technique i.e. MRI provides acute dissection anatomical information about the human soft tissues. MRI generally suffers from poor contrast, low quality due to improper brightness & blurriness. So contrast manipulation is compulsively needed. Image enhancement is taken as the initial step which defines the accuracy of result. The prime objective is to enhance the visual appearance for further image analysis i.e. detection, segmentation, feature extraction/selection and even classification. Out of all the current image enhancement methods, the appropriate choice must be influenced by the facts i.e. visual perspective, modality and climatic conditions. The noise model and the filter reconstruction mainly decide the trade-off between noise reduction and feature preservation of the original image. In this paper, Median filter (MF), Average filter (AF), Wiener Filter (WF) and Gaussian filter (GF) are used to compare the effects of most dominant noises in MR images by calculating the statistical parameters i.e. Mean Square Error, PSNR, RMSE and MAE. Also, the MR images impinge with the variable noise density for effective comparative analysis of the filters. Further, the proposed algorithm detected the tumor region appropriately.

**Keywords:** Image Enhancement, Magnetic Resonance Imaging, Peak Signal to Noise Ratio, Mean Square Error, Root Mean Square Error, Mean Absolute Error, Segmentation.

## 1. Introduction

The image enhancement considered as the best solution which improves the quality, noise reduction, contrast enhancement or all other problem that acts as a barrier during the diagnosis process [1]. MRI is one of the most powerful medical imaging modalities as per its ability to identify the abnormalities even in complex human organs so gives high sensitivity [2]. In this paper, the performances of various filtering techniques are evaluated with respect to removal of most dominant noises in MRI images with varying noise densities. The comparison is done by de-noising the impulse noise and Gaussian noise by the existing

filters i.e. Median Filter, Wiener Filter, Average Filter and Gaussian Filter. Performance evaluation is done by calculating statistical parameters i.e. MSE, PSNR, RMSE and MAE. The comparative table is analysed and then conclude the study.

## 2. Breast Cancer

Breast cancer is the most common type of cancer found especially in women. In India, the cases of breast cancer may lead to 1, 50,000 till 2020 as per IARC shown in fig. 1 [3].

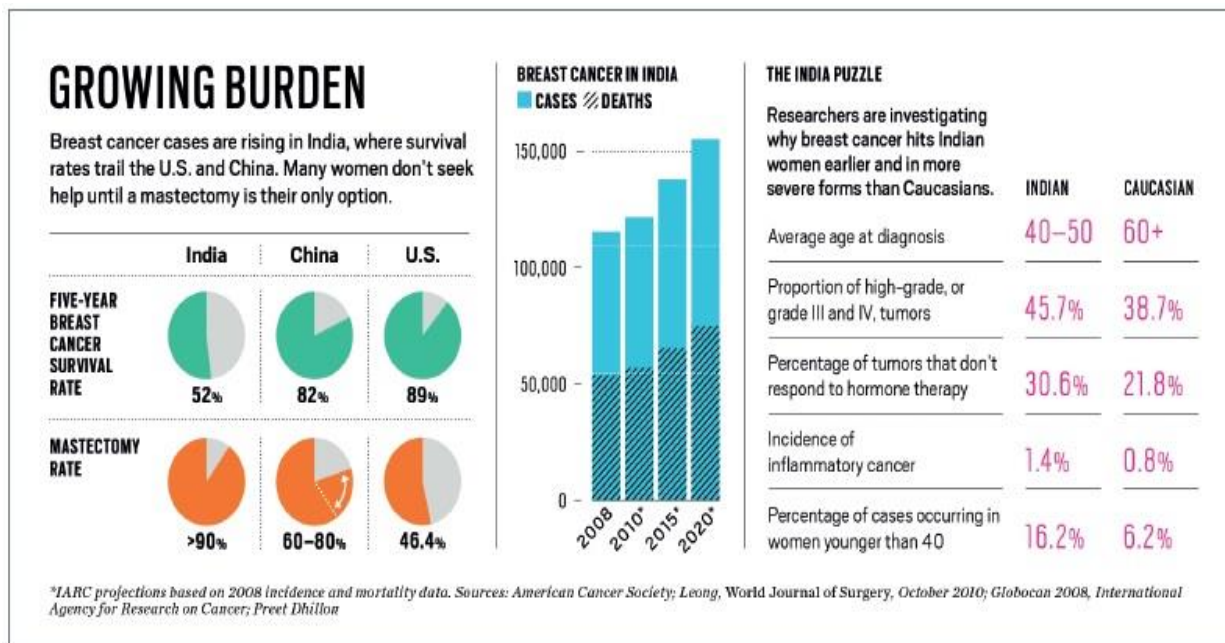


Figure 1 Growth rate [3]

### 3. Breast MRI

J Edge et. al. (2012) discussed the importance of breast MRI in screening and diagnosis of breast cancer [4]. Fig. 2 shows the Breast MRI screening tool.



Figure 2 Breast MRI Machine [5]

#### 3.1 Benign vs. Malignant Tumors

Breast tumor can be classified as benign or malignant. Some of the important features which differentiate benign tumors from malignant ones are given in table 1. Fig. 3 shows the pictorial view of both types of tumors [6]. While table 2 gives the staging of breast cancer as per their size/ extent of spread [7].

Table 1 List of features

Features	Benign	Malignant
Growth Rate	Slow	Fast
Invasion	No	Surrounding Tissues
Spreading through	No	Other body parts through lymphatic system/bloodstream
Cellular Appearance	—	Abnormal
Recurrence	Less (if so, only at the same site)	More (even to other parts)
Diagnosis	Surgery/ Radiation Therapy/ Medication	Chemotherapy/ Radiation Therapy/ Immunotherapy medication

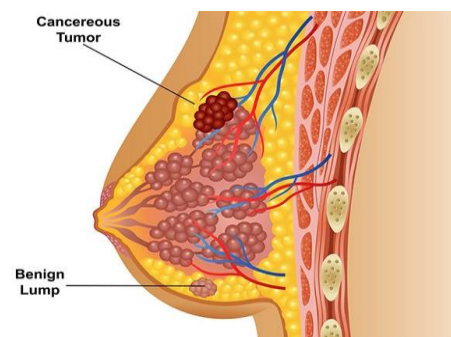


Figure 3 Benign/ malignant tumor [6]

Table 2 Size /Extent/ Staging of Breast Cancer

Type	Size	Extent of Spread	Stage
Benign (Non-invasive)	Less than 2cm	-	0
Benign (Small-invasive)	Less than 2cm	Original site	I
Malignant (Invasive)	2-5 cm	Spreading to lymph nodes	II
Malignant (large Invasive)	More than 5cm	Multiple lymph nodes/skin	III
Malignant (metastatic)	More than 5cm	Other body parts	IV

## 4. Noises in MRI

MR images often suffer from different types of noises, artefacts and inhomogeneity due to diverse reasons which hinder the imaging procedure. The brightness of the image should be uniform while the film density which is changed to form an image designated as noise [8]. There are some common sources of noise listed below:

- Lack of proper lightening
- Weather conditions
- Cleanliness / Presence of dirt
- Channel Interference

Most general classification of noises in MRI is:

**Acoustic Noise:** occurs during the rapid alterations of currents within the gradient coils i.e. Thermal noise & RF noise.

**Visual Noise:** Impulse noise, Gaussian noise, Rician noise & Speckle noise are the kinds of visual noise which gives the image grainy, mottled, snowy or textured look.

## 5. Image Enhancement Techniques

The main objective is to remove noises from MRI images while preserve the quality [9]. As a result, noise removal method can be improved and still is an open research area. Basically classified as:

- Linear Filters
- Non-linear Filters

Filters used to remove the most dominant noises are:

- Median Filters
- Average filters
- Gaussian filter
- Wiener filter

## 6. Statistical Parameters

Performance Evaluation is carried out in terms of [10]:

- **Peak signal to Noise Ratio**

$$PSNR = 10 \log_{10} \left[ \frac{\max \{I(i,j)\}^2}{\frac{1}{mn} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} [I(i,j) - K(i,j)]^2} \right] \quad (i)$$

- **Mean Square Error**

$$MSE = \frac{1}{mn} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} [I(i,j) - K(i,j)]^2 \quad (ii)$$

- **Root Mean Square Error**

$$RMSE = \sqrt{\frac{1}{mn} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} [I(i,j) - K(i,j)]^2} \quad (iii)$$

- **Mean Absolute Error**

$$MAE = \frac{1}{mn} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} |I(i,j) - K(i,j)| \quad (iv)$$



## 7. Results & Observations

Fig. 4 (a-h) shows the effect of Gaussian noise with variable noise density on breast MR image. Similarly Fig. 5 (a-h) depicts the same for impulse noise.

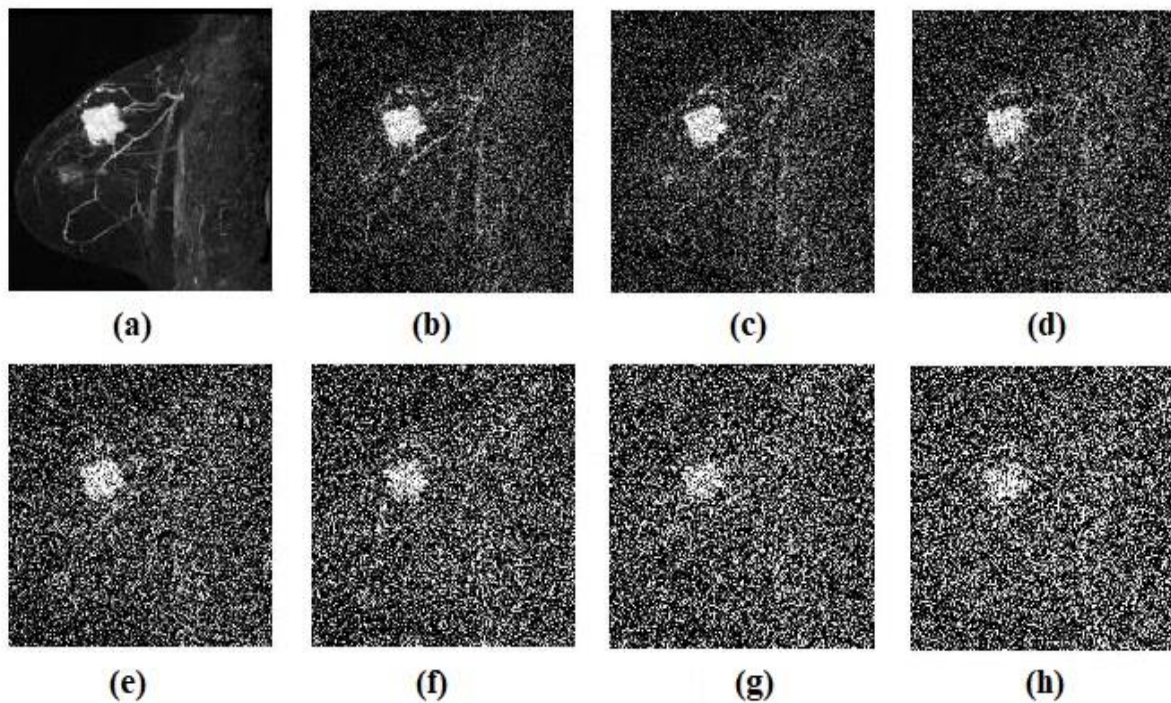


Figure 4 Effect of Gaussian noise (a) Original Breast MR image (b-h) with added noise density i.e. 0.05, 0.07, 0.1, 0.2, 0.3, 0.4, 0.5 respectively

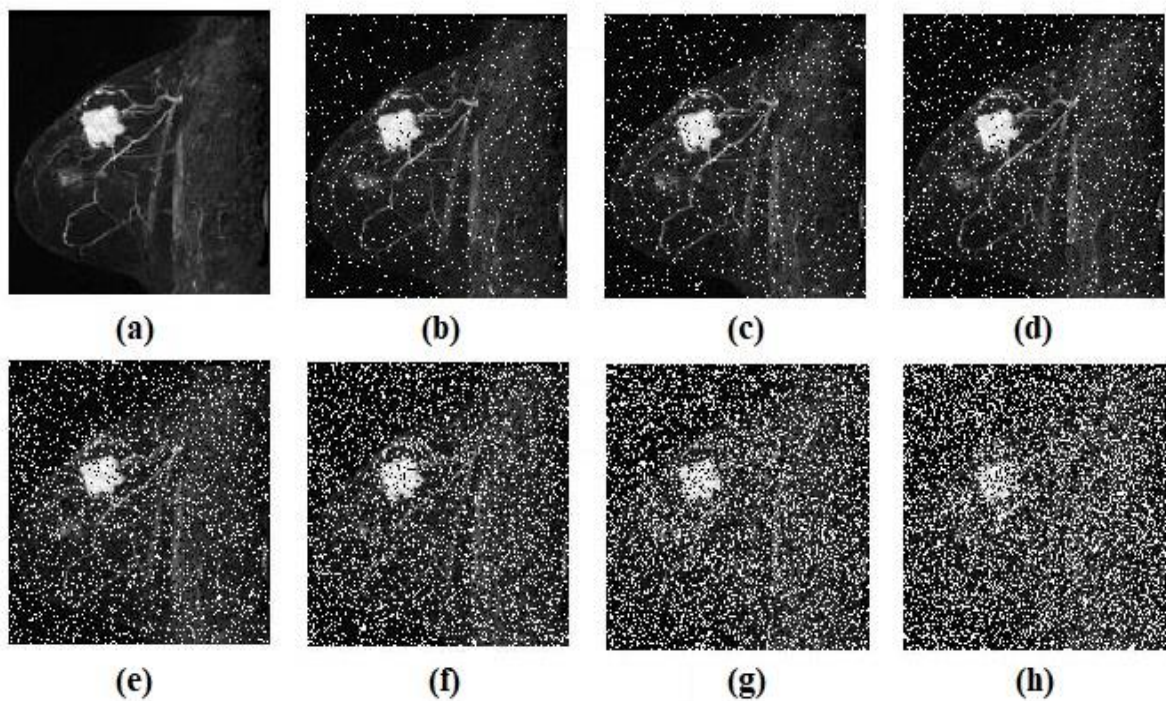


Figure 5 Effect of Impulse noise (a) Original Breast MR image (b-h) with added noise density i.e. 0.05, 0.07, 0.1, 0.2, 0.3, 0.4, 0.5 respectively

The original breast MR image impinges with Impulse/Gaussian noise may be evaluated in terms of various statistical parameters like MSE, PSNR, RMSE and MAE. While the parameters gives the improved results

when evaluated for the filtered image either by median filter or wiener filter. The above mentioned filters are the best for image enhancement. The results are shown in fig. 6.

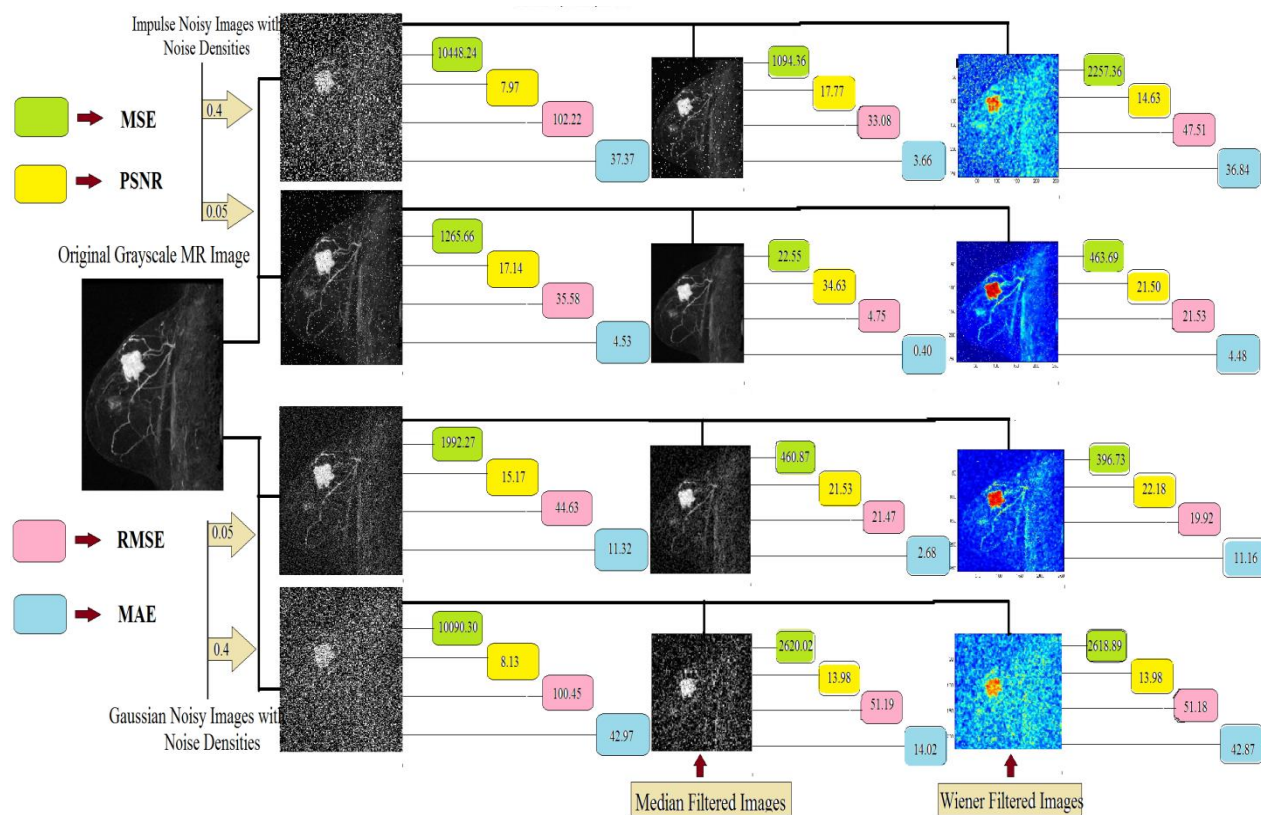


Figure 6 Image enhancements through filtering: Median filter and Wiener filter

Table 3.1 and 3.2 shows the quantitative analysis of Impulse noise and Gaussian noise added breast MR image of noise densities varying in between 0.05 to 0.5 for various filtering techniques respectively.

Table 3.1 Quantitative Analysis of Impulse noise added breast MR image of noise densities varying in between 0.05 to 0.5

	MSE							PSNR						
	0.05	0.07	0.1	0.2	0.3	0.4	0.5	0.05	0.07	0.1	0.2	0.3	0.4	0.5
Impulse Noisy	1265.7	1770.9	2642.5	5235.4	7853.1	10448.2	13020	17.14	15.68	13.95	10.98	9.21	7.97	7.02
Median Filtered	21.55	24.48	29.63	84.07	375.35	1094.36	2550.26	34.68	34.28	33.45	28.92	22.42	17.8	14.1
Average filtered	192.67	263.2	416.5	955.14	1689.1	2572.08	3607.31	25.32	23.96	21.97	18.36	15.39	14.1	12.59
Gaussian filtered	542.77	756.69	1158.1	2590.2	3771.8	5235.53	6199.33	20.82	19.38	17.53	14.38	12.4	11	9.84
Wiener filtered	463.69	518.68	662.99	1031.1	1563.1	2257.36	3090.96	21.5	21.02	19.95	18.03	16.22	14.6	13.26
	RMSE							MAE						
	0.05	0.07	0.1	0.2	0.3	0.4	0.5	0.05	0.07	0.1	0.2	0.3	0.4	0.5
Impulse Noisy	35.58	42.08	51.4	72.36	88.62	102.22	114.11	4.53	6.31	9.45	18.85	27.98	37.4	45.39



<b>Median Filtered</b>	4.75	4.95	5.44	9.17	19.37	33.08	50.5	0.4	0.42	0.45	0.56	1.43	3.66	8.73
<b>Average filtered</b>	13.88	16.22	20.41	30.91	41.1	50.72	60.06	4.46	6.2	9.33	18.67	27.76	37	45.03
<b>Gaussian filtered</b>	23.3	27.51	34.03	48.89	61.42	72.36	82.46	4.51	6.27	9.41	18.83	27.97	37.3	45.28
<b>Wiener filtered</b>	21.53	22.77	25.75	32.11	39.54	47.51	55.6	4.48	6.2	9.35	18.4	27.57	36.8	45.06

Table 3.2 Quantitative Analysis of Gaussian noise added breast MR image of noise densities varying in between 0.05 to 0.5

	MSE							PSNR						
	0.05	0.07	0.1	0.2	0.3	0.4	0.5	0.05	0.07	0.1	0.2	0.3	0.4	0.5
<b>Gaussian Noisy</b>	1992.27	2713.54	3635.08	6388.74	8435.59	10090.3	11155.35	15.17	13.83	12.56	10.11	8.9	8.13	7.69
<b>Median Filtered</b>	460.87	608.58	778.33	1424.63	2010.55	2620.53	3136.43	21.53	20.32	19.25	16.63	15.13	13.98	13.2
<b>Average filtered</b>	405.57	583.19	810.91	1658.28	2364.94	3001.62	3430.52	22.08	20.51	19.01	15.97	14.42	13.39	12.81
<b>Gaussian filtered</b>	919.21	1292.8	1751.77	3246.99	4419.77	5400.39	6037.37	18.48	17.05	15.73	13.05	11.71	10.84	10.36
<b>Wiener filtered</b>	397.73	559.83	759.7	1482.62	2076.33	2613.89	2983.52	22.18	20.68	19.36	16.45	14.99	13.98	13.42
	RMSE							MAE						
	0.05	0.07	0.1	0.2	0.3	0.4	0.5	0.05	0.07	0.1	0.2	0.3	0.4	0.5
<b>Gaussian Noisy</b>	44.63	52.09	60.29	79.93	91.85	100.45	105.62	11.32	15.05	18.99	30.14	37.3	42.97	45.42
<b>Median Filtered</b>	21.47	24.67	27.9	37.34	44.84	51.19	56	2.68	3.51	4.08	8.14	11.09	14.02	15.02
<b>Average filtered</b>	20.14	24.15	28.48	40.73	48.64	54.79	58.57	11.19	14.89	18.8	29.91	37.01	42.65	45.03
<b>Gaussian filtered</b>	30.48	35.96	43.85	56.98	66.48	73.49	77.7	11.28	15	18.93	29.92	37.21	42.87	45.31
<b>Wiener filtered</b>	19.92	23.66	27.56	38.5	45.67	51.18	54.62	11.16	14.87	18.69	29.6	35.81	42.45	45.85

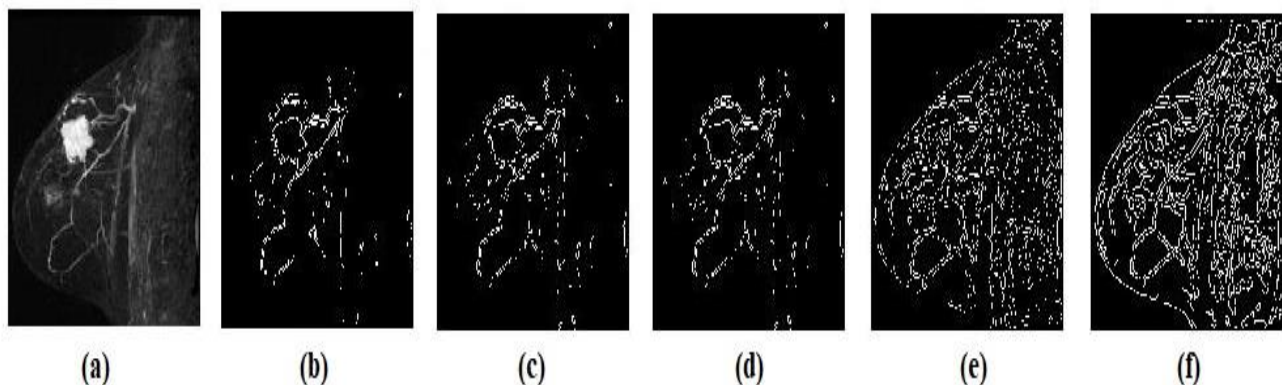


Figure 7 Edge detection (a) Original breast MR image (b) Robert (c) Sobel (d) Prewitt (e) Logrithmic (f) Canny

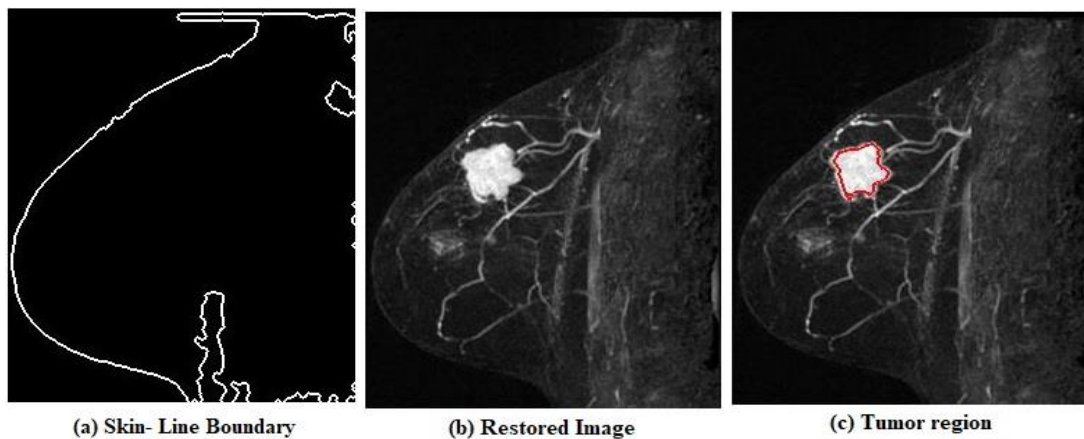


Figure 8. Tumor detection (a) Skin Line boundary (b) Restored Image (c) Tumor region detection

## 8. Conclusion

Firstly, this paper investigated the Gaussian noise as the most dominant noise in MR Images at low noise density (0.05-0.2) while both the Impulse and Gaussian noise become equally dominant at higher noise densities (0.25-0.5) on the basis of various statistical parameters like MSE, PSNR & RMSE. Secondly, the performance evaluation of four different filtering methods on most dominant noises is done & then concluded that the median filter is better to reduce Impulse noise while the wiener filter is better to remove Gaussian noise at lower noise density when analysed with MSE, PSNR & RMSE while at higher noise density as well as analysis with MAE states that the Median filter is the best one when contrasted with different filters for reduction of Gaussian noise. The outcomes demonstrated that MF gives alluring outcomes with higher PSNR esteem for MR image de-noising. As the AF expels additive type of noises and de-obscuring simultaneously, consequently it has a critical capacity to enhance the decrease of the general MSE. Through this examination, it has been seen that the selection of filter for de-noising the MR images relies upon the kind of noise and the filtering method used.

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