CHAPTER 4
EXPERIMENTAL RESULTS FOR BRAIN TUMOR DETECTION

This includes different stages simulation results. All the algorithms are implemented in Software and executed on the Core i3, 1.73GHz CPU with 512 GB hard disk. Image Processing toolbox, Wavelet Toolbox, etc. available in Software. There are four stages in the research work, Image Acquisition (Image Dataset), First Stage is Pre-processing, Second stage is Segmentation, Third stage is Feature Extraction and Fourth stage is Feature Classification. In the Image dataset, from where images was taken for research work. For the First stage of Pre-processing, in these wiener filter, anisotropic filter, median filter, non-local means filter and combined filters was used and compares the results using statistical parameters, like Peak Signal to Noise Ratio, Mean Square Error, Root Mean Square Error and Universal Quality Index. For the Second stage of the Segmentation, in these cuckoo search algorithm with four different objective functions, Otsu, Kapur Entropy, Tsallis Entropy and combined Otsu and Tsallis Entropy was used and compared the results.

4.1 IMAGE DATASET

1) To validate the accuracy and efficiency of the proposed algorithm for brain tumor detection and classification from the kaggle dataset (www.kaggle.com) is considered. From kaggle dataset, for validation 600 brain images, out of 400 brain tumor images and 200 no tumor images are considered. Figure 4.1 shows the sample Image of the Brain MRI Image from the kaggle dataset is,

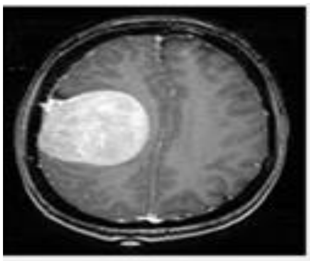

Figure 4.1 : Sample Brain MRI Image-1

2) MRI (1.5Tesla, 16 Channels) Brain images taken from "**Sahyog Imaging Centre, SSG Hospital, Baroda Medical College, The Maharaja Sayajirao University of the Baroda, Vadodara, Gujarat, India."** From the Sahyog Imaging Centre 50 patients data are collected

for validation. In this 30 males and 20 females patients, 450 brain tumor images and 250 no tumor images are validated. Figure 4.2 shows the sample Image of the Brain MRI Image from the patient data is,

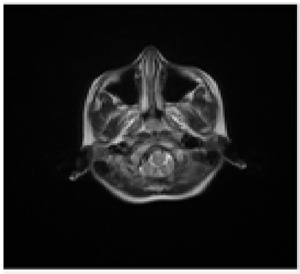

Figure 4.2 : Sample Brain MRI Image-2

4.2 PRE-PROCESSING OF THE FILTERING ALGORITHMS

In this part, compare the different filter outputs of the Brain MRI Images. Find the statistical parameters of the Median Filter, Anisotropic Filter, Wiener Filter, Non Local Means Filter, different combined filters and compare the parameters for the different filters.

4.2.1 FILTER OUTPUT OF THE BRAIN MRI IMAGES

Figure 4.3 to Figure 4.18 shows the different filter outputs; wiener filter, anisotropic filter, median filter, non-local means filter and combined filters for different types of T1 and T2 Brain MRI Images with different area.

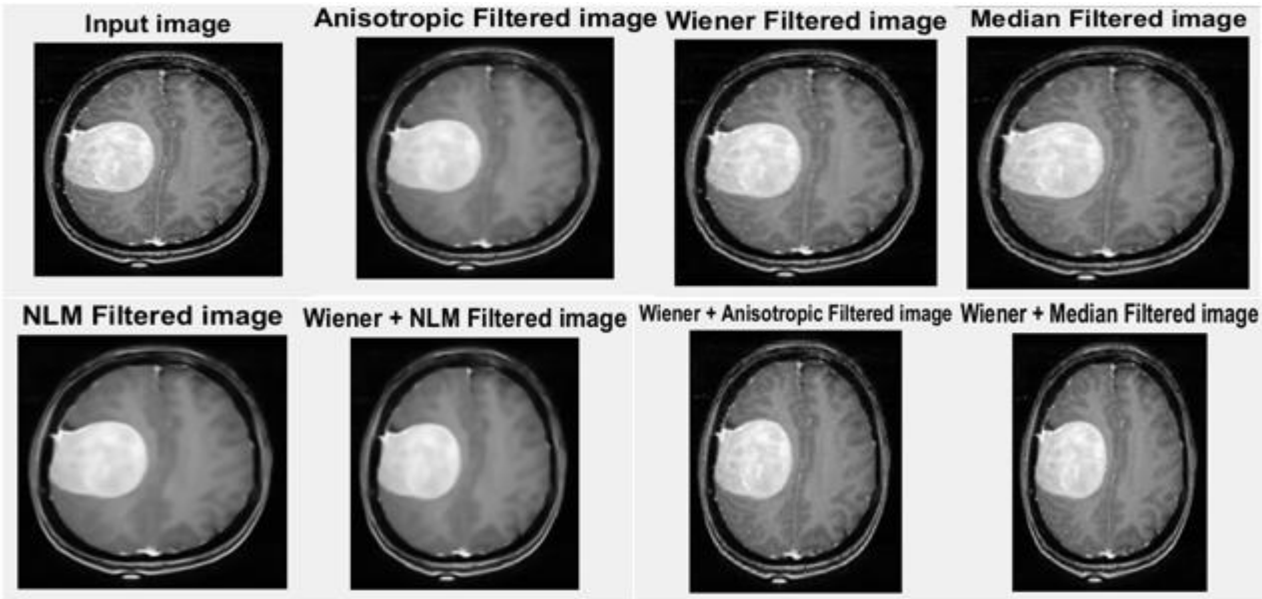

Figure 4.3 : Result for T1 weighted Image-1 after applying Different Filtering Techniques

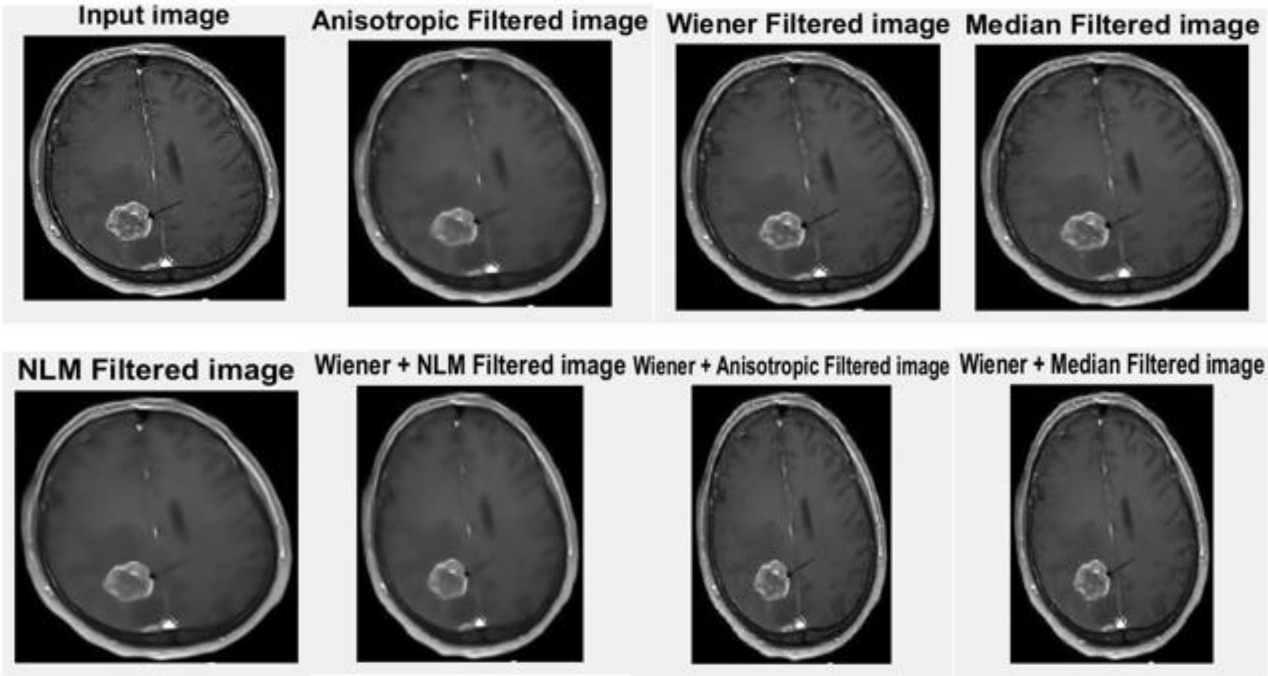

Figure 4.4 : Result for T1 weighted Image-2 after applying Different Filtering Techniques

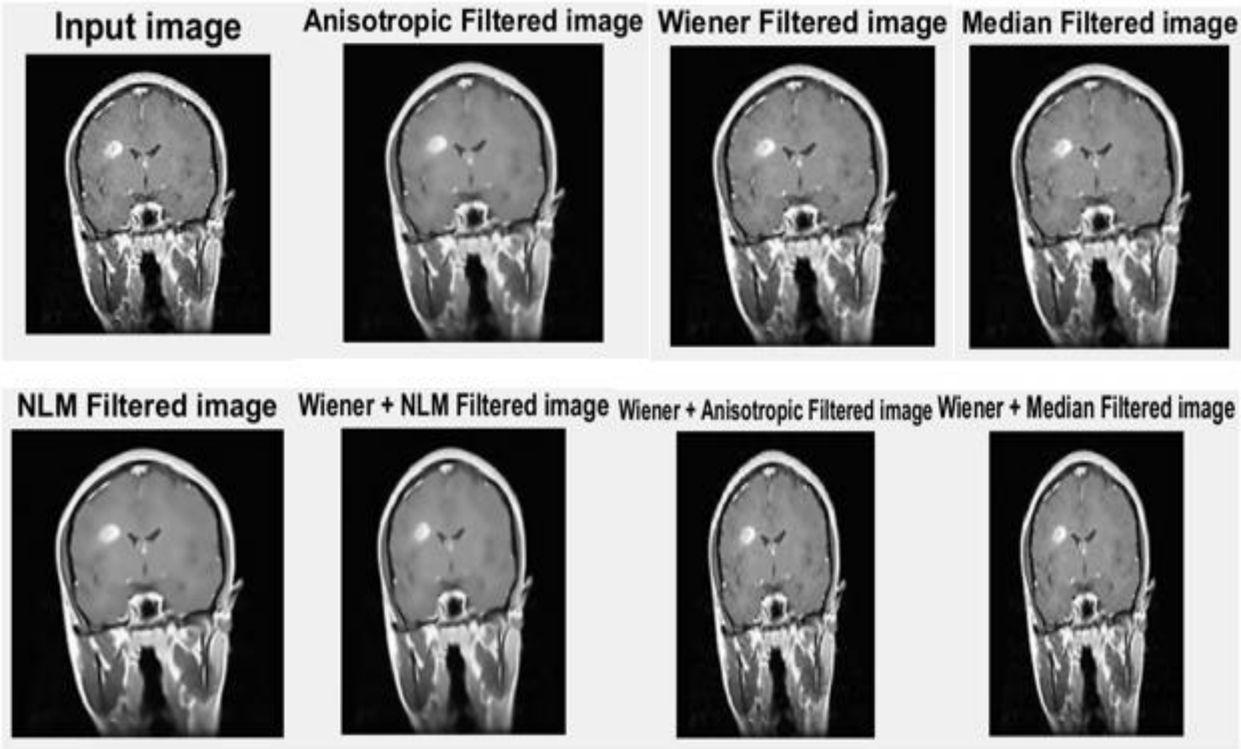

Figure 4.5 : Result for T1 weighted Image-3 after applying Different Filtering Techniques

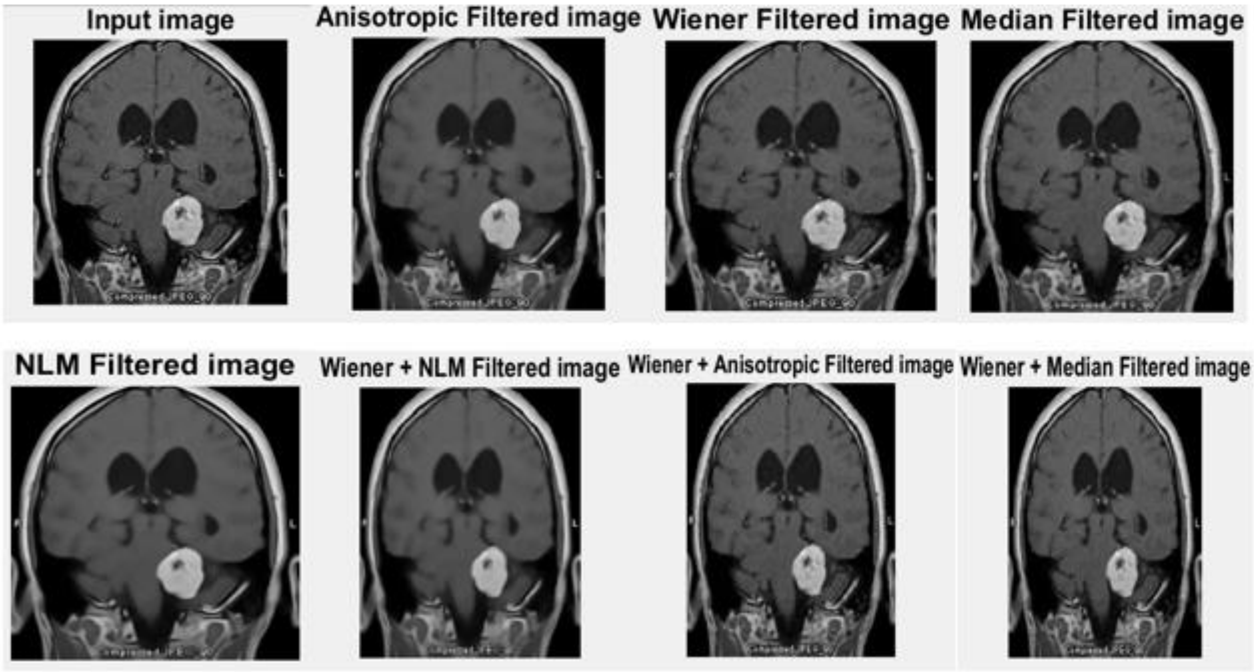

Figure 4.6 : Result for T1 weighted Image-4 after applying Different Filtering Techniques

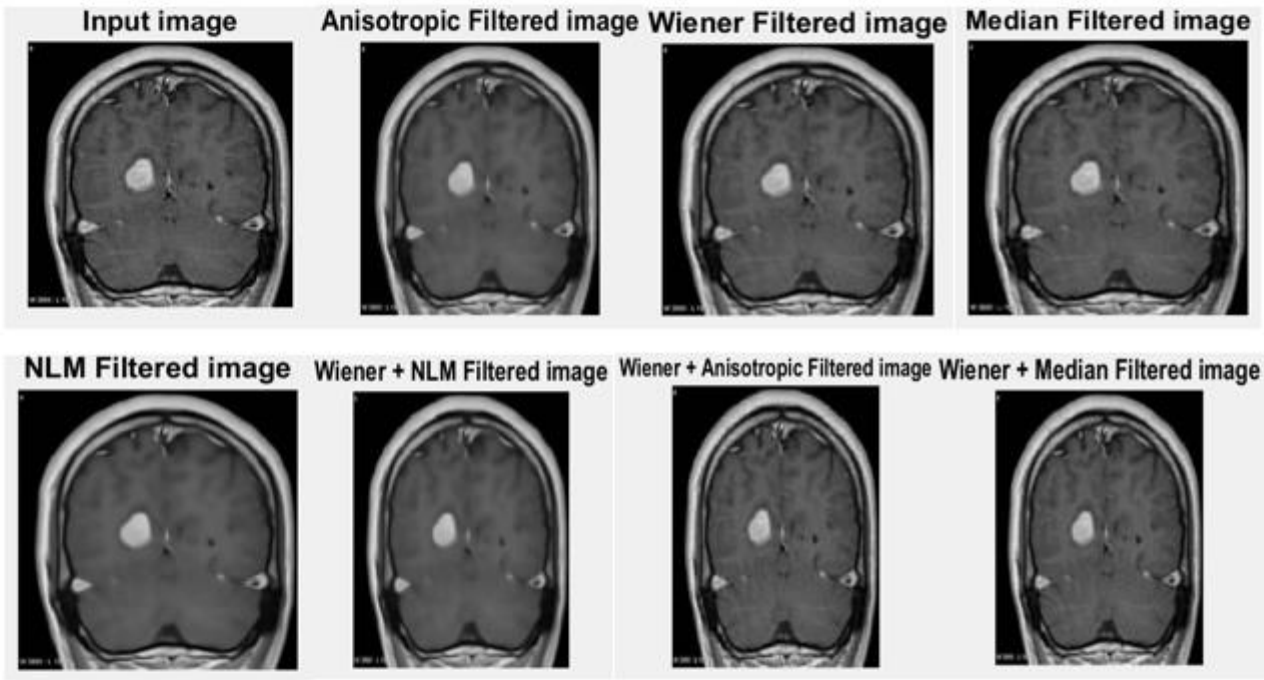

Figure 4.7 : Result for T1 weighted Image-5 after applying Different Filtering Techniques

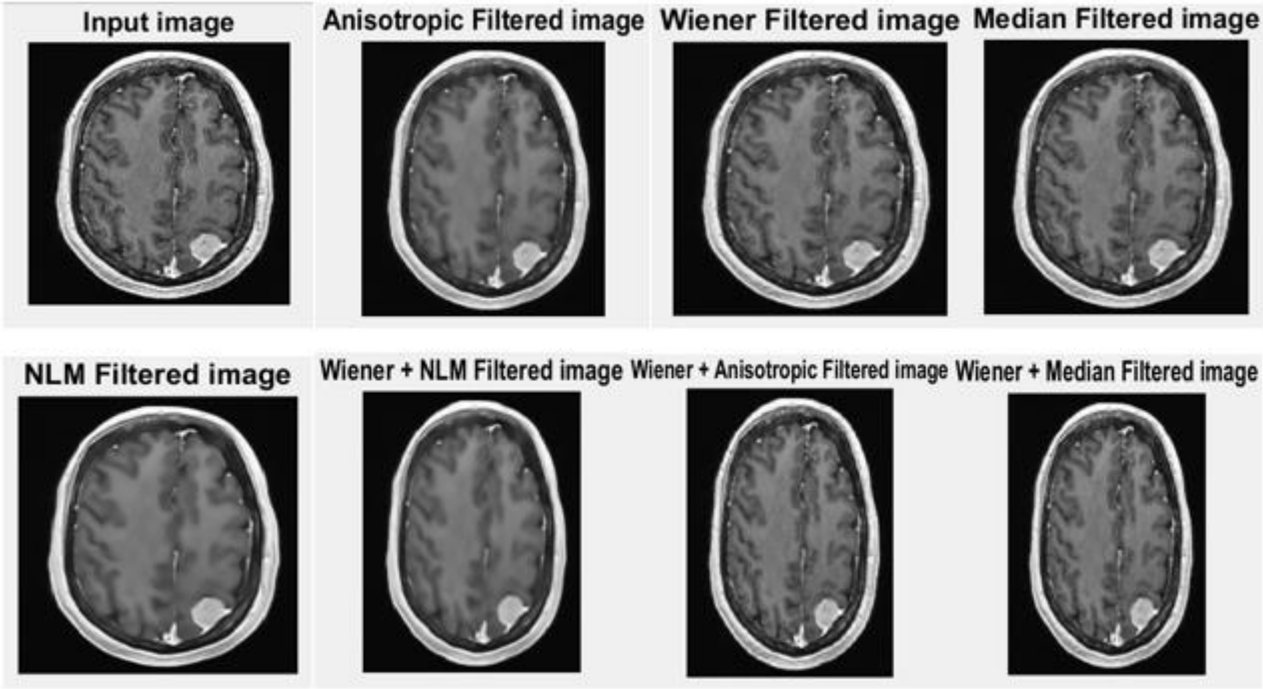

Figure 4.8 : Result for T1 weighted Image-6 after applying Different Filtering Techniques

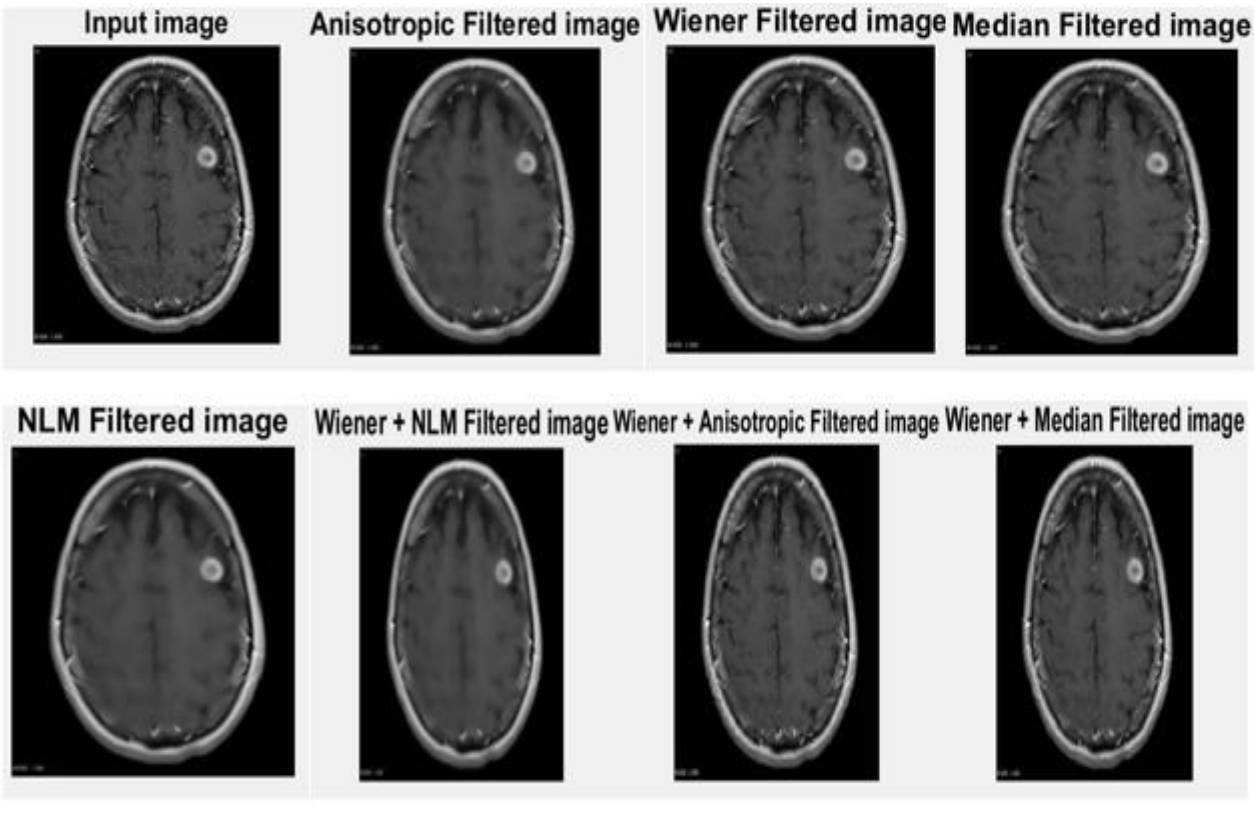

Figure 4.9 : Result for T1 weighted Image-7 after applying Different Filtering Techniques

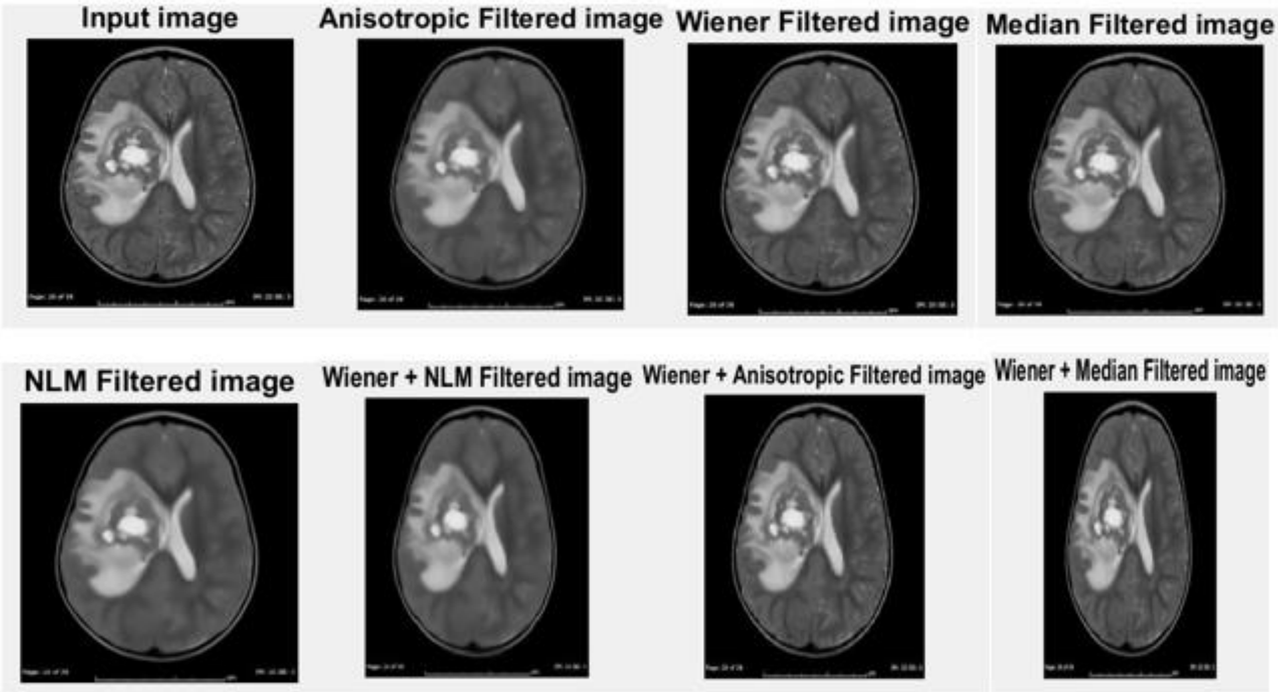

Figure 4.10 : Result for T2 weighted Image-8 after applying Different Filtering Techniques

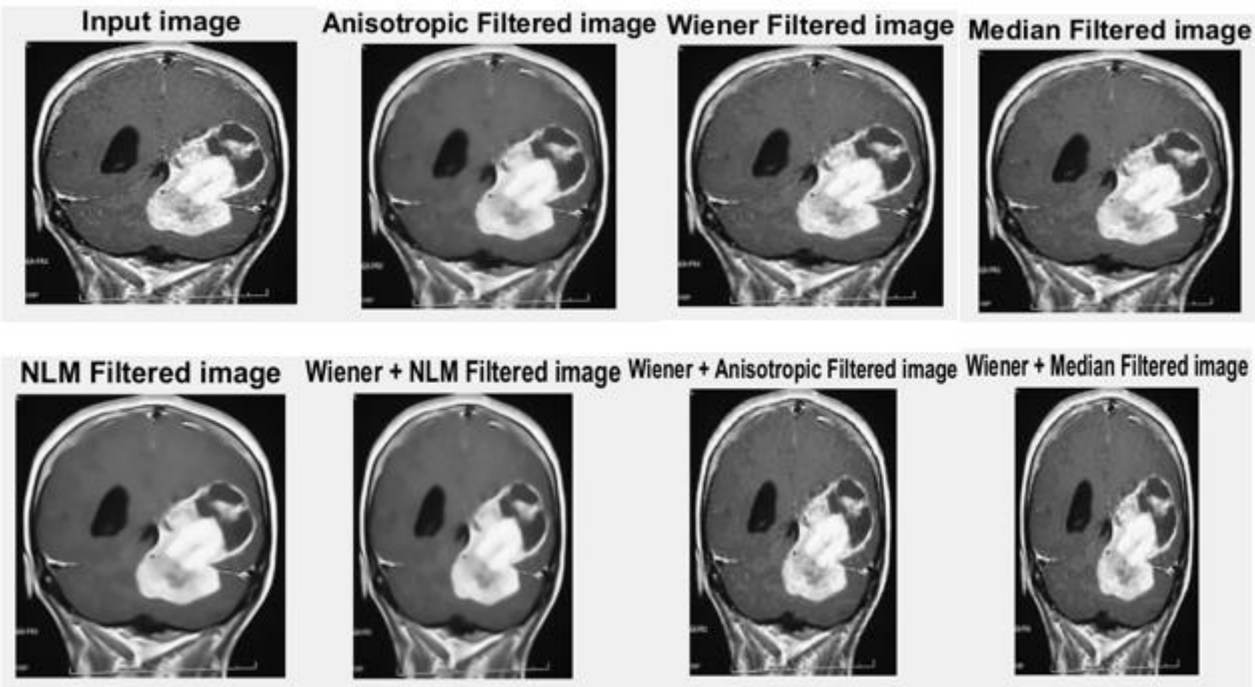

Figure 4.11 : Result for T1 weighted Image-9 after applying Different Filtering Techniques

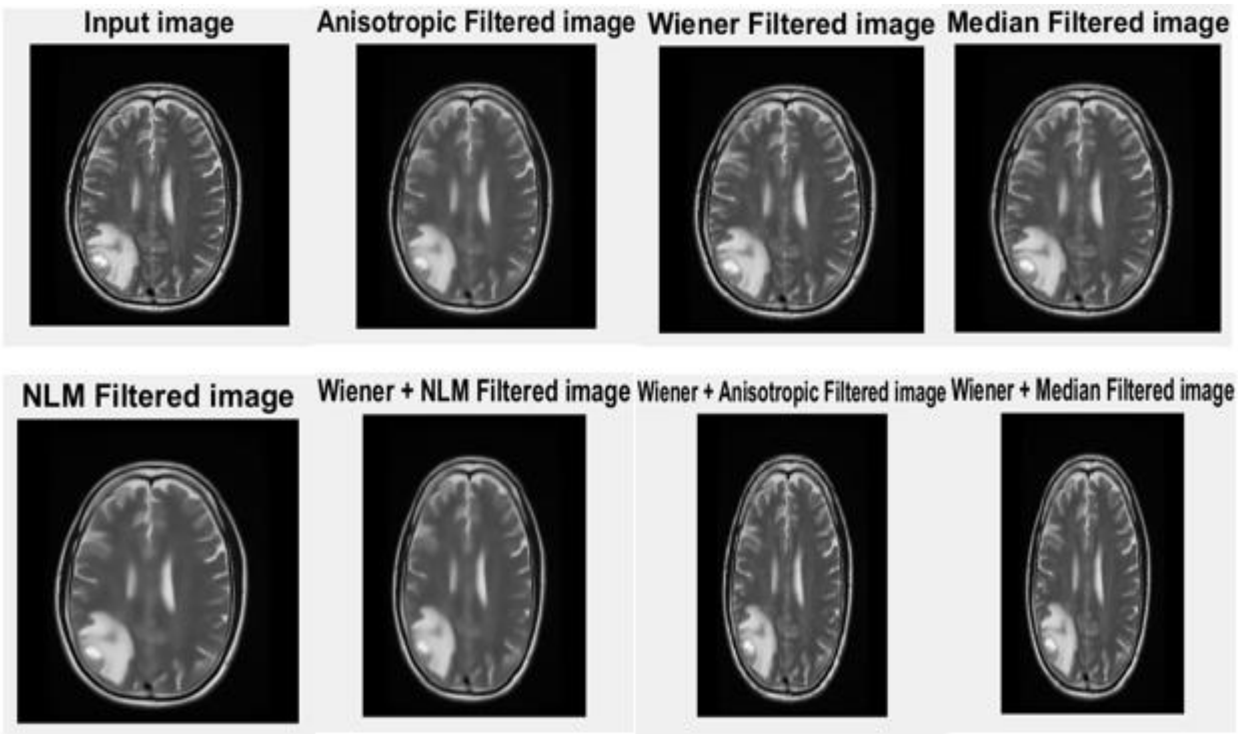

Figure 4.12 : Result for T2 weighted Image-10 after applying Different Filtering Techniques

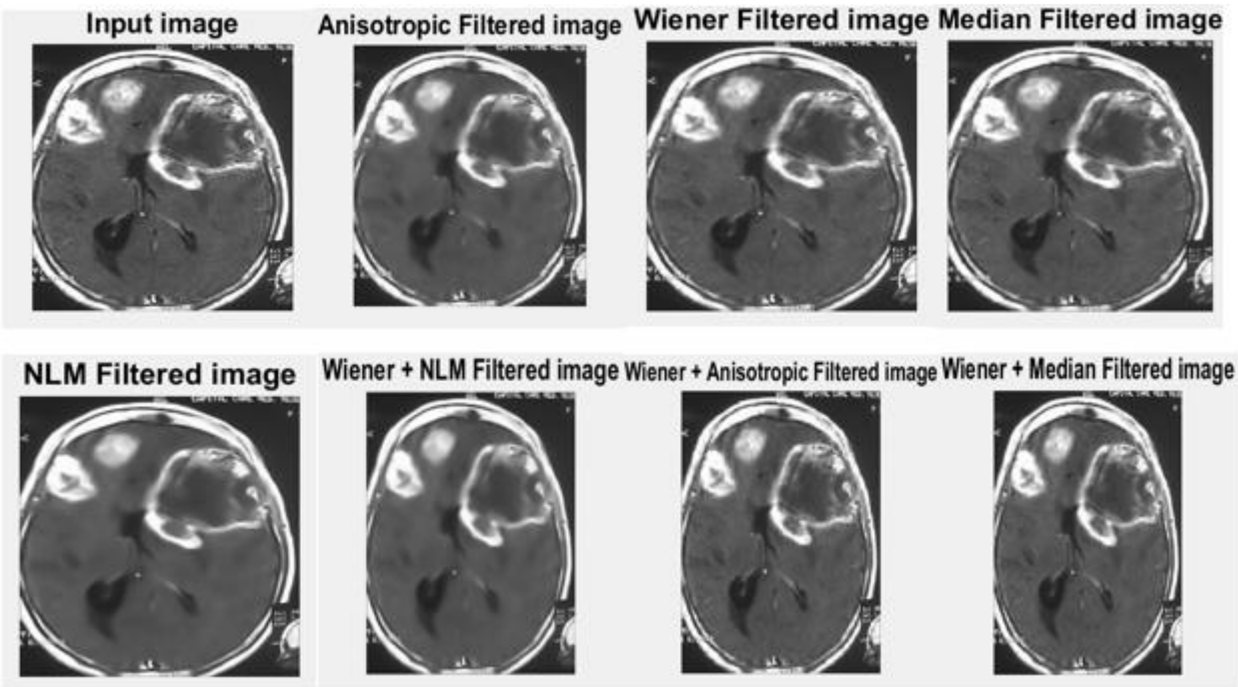

Figure 4.13 : Result for T1 weighted Image-11 after applying Different Filtering Techniques

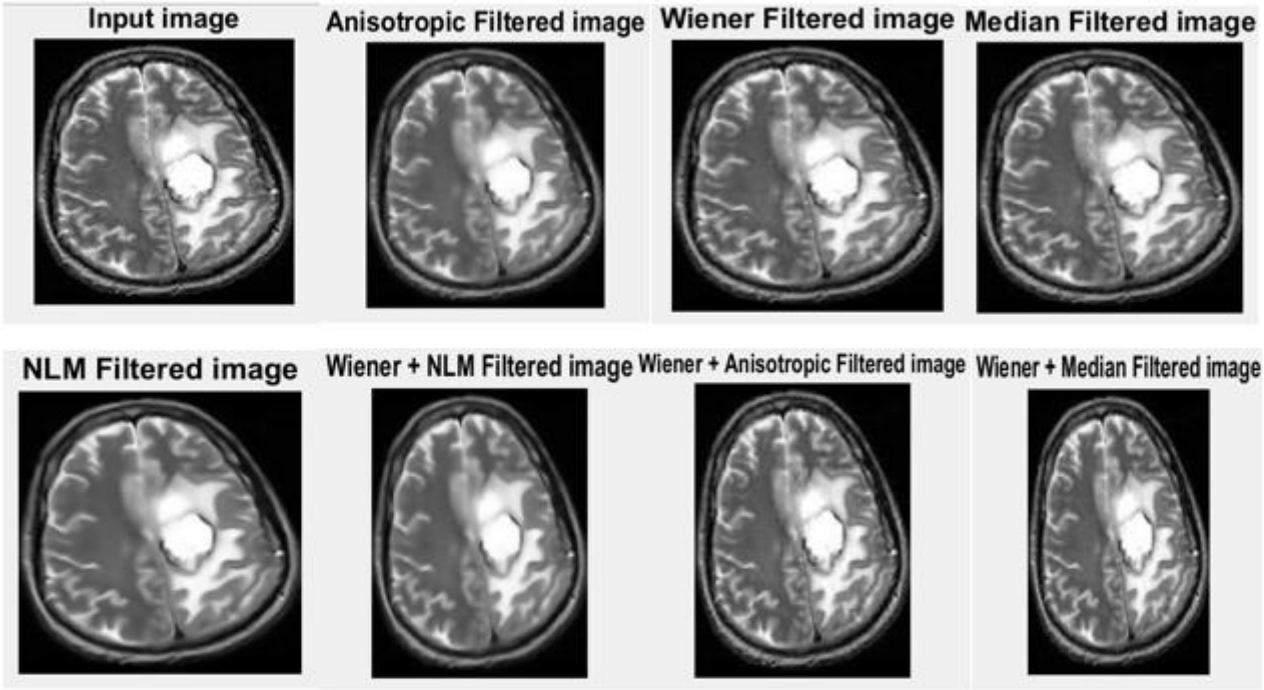

Figure 4.14 : Result for T2 weighted Image-12 after applying Different Filtering Techniques

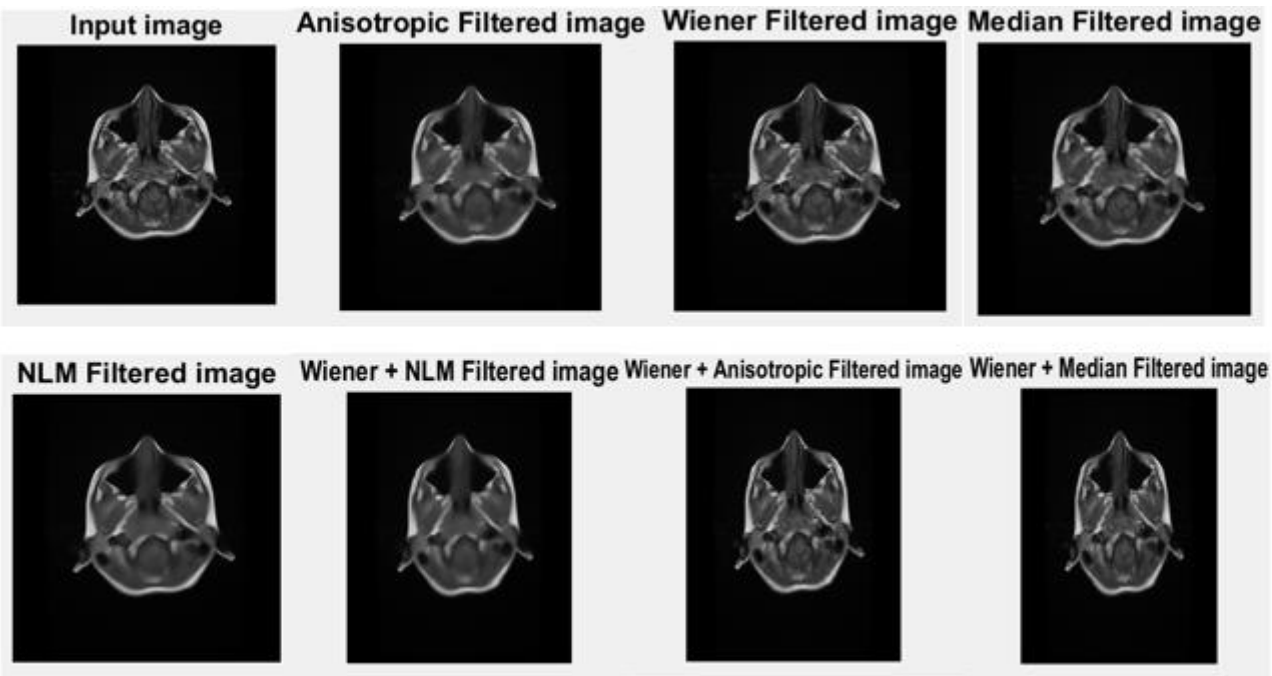

Figure 4.15 : Result for T1 weighted Image-13 after applying Different Filtering Techniques

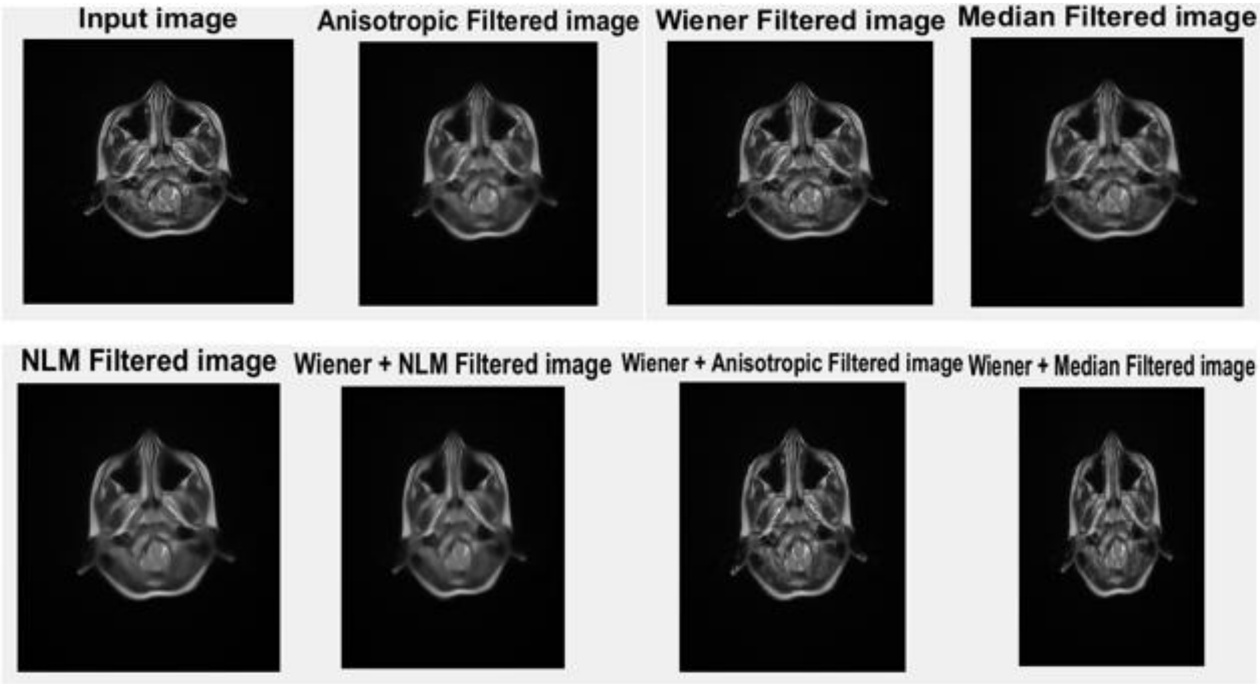

Figure 4.16 : Result for T2 weighted Image-14 after applying Different Filtering Techniques

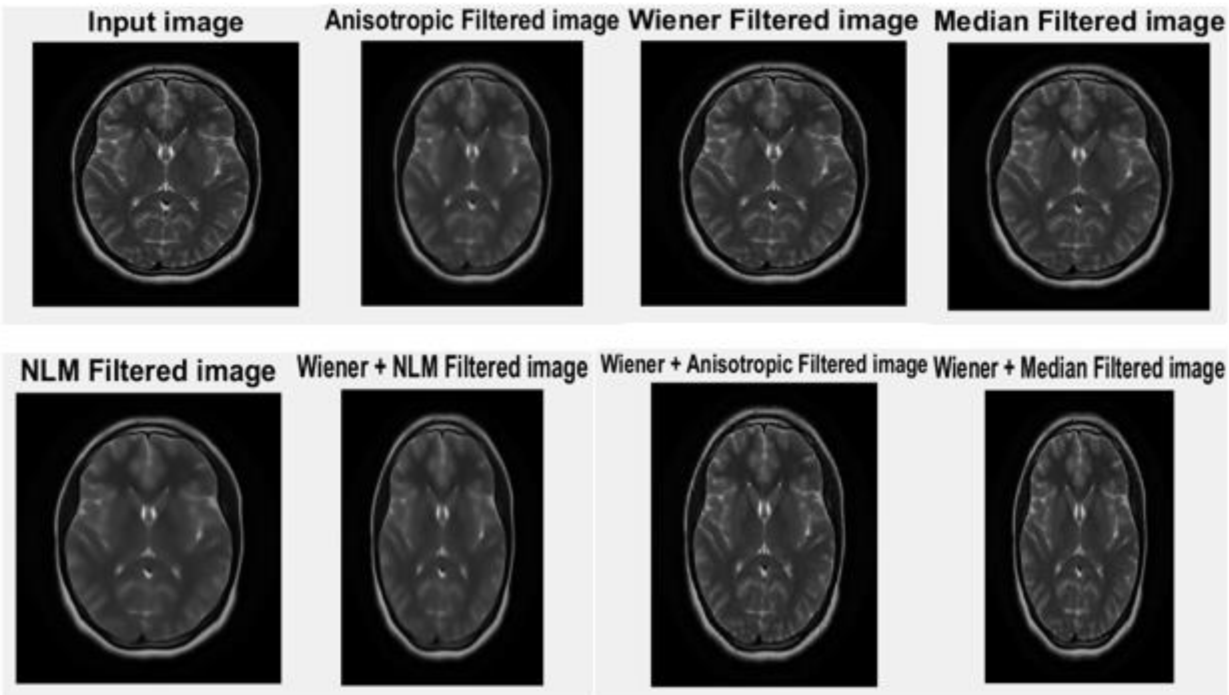

Figure 4.17 : Result for T2 weighted Image-15 after applying Different Filtering Techniques

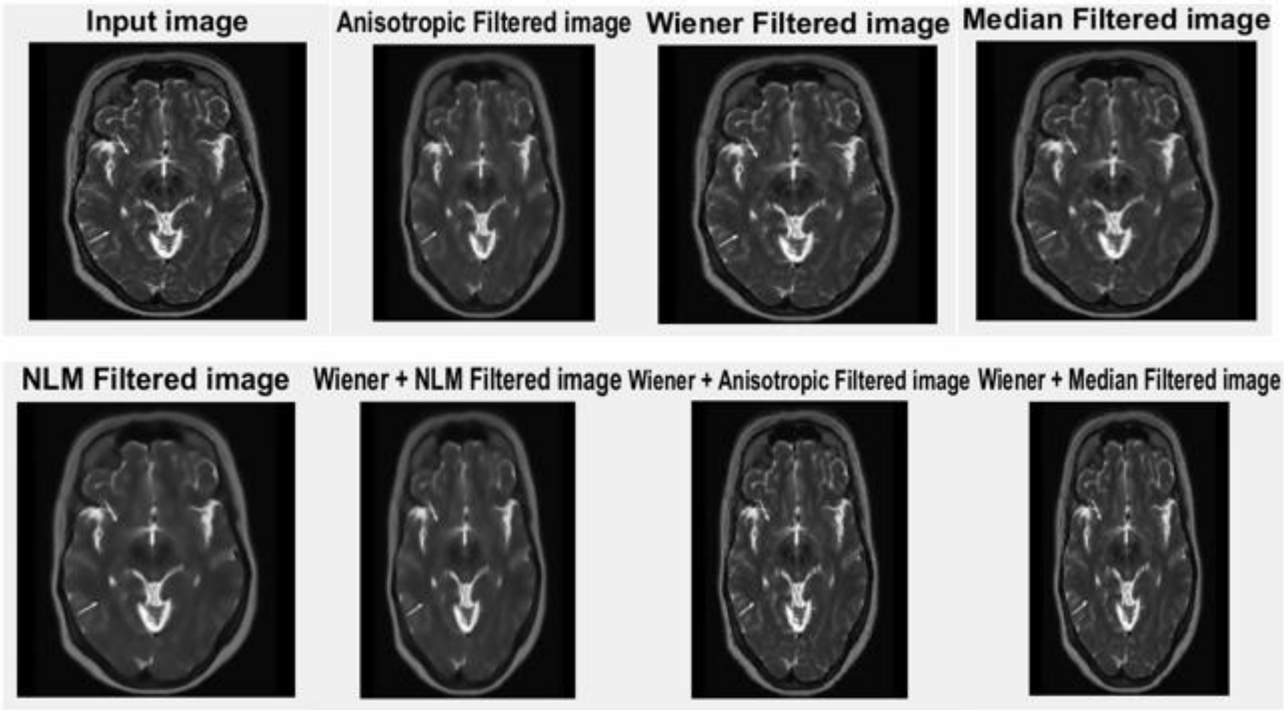

Figure 4.18 : Result for T2 weighted Image-16 after applying Different Filtering Techniques

4.2.2 STATISTICAL PARAMETERS OF THE FILTERS

In the research work implementation of the specific filters as well as the combining of filters are employed using statistical parameters. The description of parameters implemented for different Brain MRI Images is given below [69]:

PEAK SIGNAL TO NOISE RATIO: The PSNR block computes the peak signal-to-noise ratio, in decibels, between two images. The PSNR is used as a quality measurement between the original and a filtered image. The statistic used to evaluate it is the decibels (dB). The higher the PSNR, the better the quality of the filtered image. PSNR is defined as:

$$PSNR = \frac{10\, log 255^2}{MSE} \quad \ldots (4.1)$$

MEAN SQUARE ERROR: The MSE represents the cumulative squared error between the filtered and the original image. p_{ij} is the original image and q_{ij} is the filtered image. The input image, pij, and the filtered output image, qij, are both M × N in dimension. Summarizing the values of i and j represents the total number of pixels in the image, whereas M and N represent the number of rows and columns in the original image. The dimension is at its smallest when the images are nearly similar. Smaller the MSE then better quality of filtered image. MSE is defined as:

$$MSE = \frac{\sum_{j=1}^{N}\left(\sum_{i=1}^{M}(p_{ij}-q_{ij})^2\right)}{MN} \qquad \ldots (4.2)$$

ROOT MEAN SQUARE ERROR: RMSE is the square root of the mean of the square of all of the error. Smaller the RMSE then better quality of filtered image. RMSE is defined as:

$$RMSE = \sqrt{MSE} \qquad \ldots (4.3)$$

UNIVERSAL QUALITY INDEX: The ideal outcome although is 1 and the dynamic scale is [-1,1]. It corrects for incoherence, brightness distortion, and intensity disturbance in one parameter. Assume that $p = \{p_i \mid i = 1, 2, \ldots\ldots N\}$ and $q = \{q_i \mid i = 1, 2, \ldots\ldots N\}$ is the original and filtered image values, respectively. According to the suggested quality index's description:

$$UQI = \frac{4\,\sigma_{pq}\;\bar{p}\,\bar{q}}{(\sigma_p^2+\sigma_q^2)(\bar{p}^2_+\,\bar{q}^2\,)} \qquad \ldots (4.4)$$

where,

$$\bar{p} = \frac{1}{N}\sum_{i=1}^{N} p_i\ , \qquad \bar{q} = \frac{1}{N}\sum_{i=1}^{N} q_i$$

$$\sigma_p^2 = \frac{1}{N-1}\sum_{i=1}^{N}(p_i-\bar{p}\,)^2\,, \qquad \sigma_q^2 = \frac{1}{N-1}\sum_{i=1}^{N}(q_i-\bar{q}\,)^2$$

$$\sigma_{pq} = \frac{1}{N-1}\sum_{i=1}^{N}(p_i-\ \bar{p}\,)\,(q_i-\ \bar{q}\,)$$

The PSNR that is measured in dB and represents the best possible signal-to-deformed-noise ratio, output to be higher in value. To calculate PSNR, various filters such as Median, Wiener, Anisotropic, Non-Local Median and filter combinations are utilised. Out of all the individual filters, the Wiener filter produced the best results. It was therefore continued for further filter combinations. Figure 4.19

reflects the PSNR result for seven distinct cases of individual filters and combined filters. The PSNR result of the Median Filter was 30.15801 dB, the Wiener filter is 35.20005 dB, the Anisotropic filter was 32.3954 dB and the NLM filter was 30.73707 dB. The mean result of Wiener and NLM was 35.95141 dB, Wiener and Anisotropic was 37.37613 dB and Wiener and Median was 35.88817 dB while taking into account the combination of filters. Combined Wiener and Anisotropic filter PSNR got highest value.

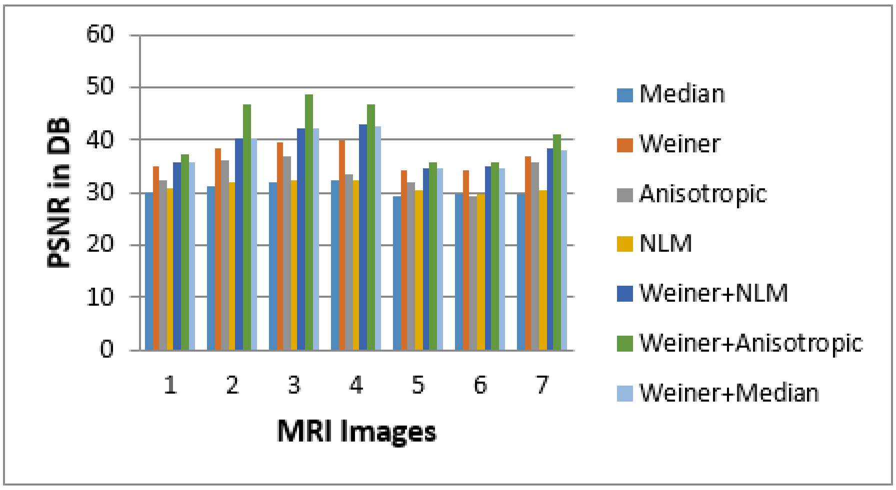

Figure 4.19 : PSNR of the Brain Images after applying Different Filtering Techniques

MSE is used to determine the mean square of errors for both the actual and intended scans. The MSE value, must be as low as possible to obtain an accurate image. Figure 4.20 shows the MSE for each unique filter and combined filters for seven distinct cases. The Median filter had a MSE value of 63.19438, Wiener filter of 19.79131, Anisotropic filter of 37.75201 and NLM filter of 55.30606. The MSE result of Wiener and NLM was 16.64712, Wiener and Anisotropic was 11.99131, and Wiener and Median was 16.89131 when the combination of filters was taken into account. Combined Wiener and Anisotropic filter MSE got lowest value.

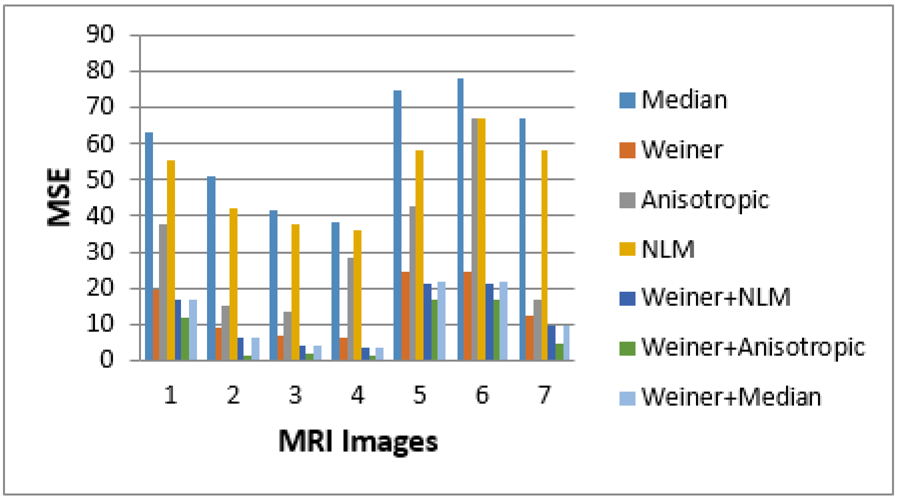

Figure 4.20 : MSE of the Brain Images after applying Different Filtering Techniques

It is common procedure to quantify inconsistency using the Root Mean Squared Error must be kept to a low to ensure good output. Figure 4.21 shows the RMSE for each unique filter and combined filters for seven distinct cases. The mean RMSE values of the Median filter, Wiener filter, Anisotropic filter and NLM filter was 7.94949, 4.44874, 7.4368 and 6.14427, respectively. Wiener and NLM had a mean RMSE value of 4.08009, Wiener and Anisotropic had a mean RMSE value of 3.46285, and Wiener and Median had a mean RMSE value of 4.1099 when the combination of filters is taken into account. Combined Wiener and Anisotropic filter RMSE got lowest value.

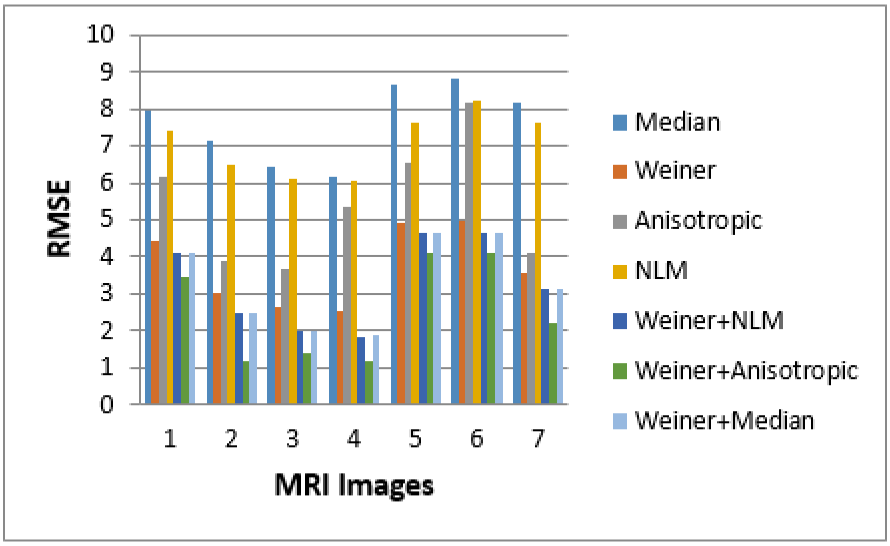

Figure 4.21 : RMSE of the Brain Images after applying Different Filtering Techniques

The Universal Image Quality Index of the filter is evaluated and is ought to be higher for improved noise - reducing quality. UQI values of the single filter and combined filters for seven separate cases is shown in Figure 4.22. The mean UQI values of the Median Filter, Wiener Filter, Anisotropic Filter and NLM Filter was 0.7293, 0.91696, 0.92288 and 0.68378 respectively. The Mean UQI values of Wiener and NLM was 0.92966, Wiener and Anisotropic was 0.96896, and Wiener and Median was 0.92896 when the combination of filters was taken into account. Combined Wiener and Anisotropic filter UQI got highest value.

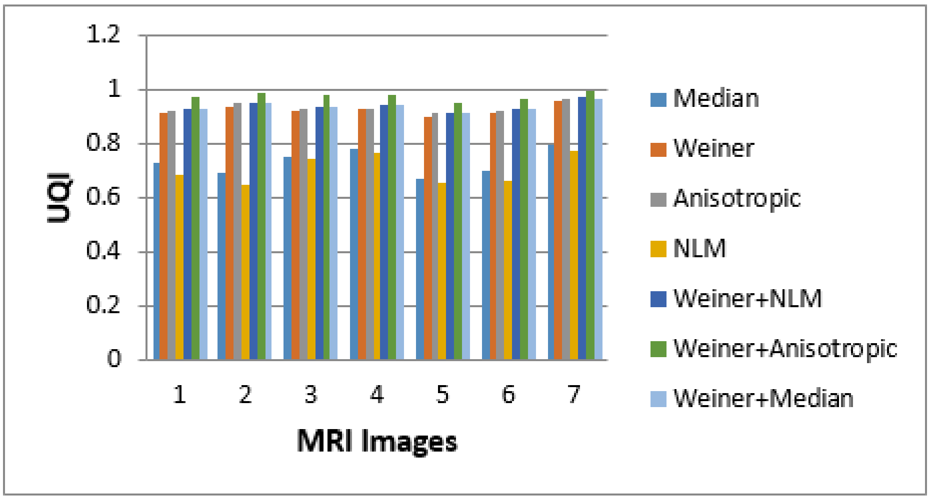

Figure 4.22 : UQI of the Brain Images after applying Different Filtering Techniques

Different filters also implemented on DICOM images. Figure 4.23 reflects the PSNR result for seven distinct cases of individual filters and combined filters. The mean PSNR value of the Median Filter was 33.76693 dB, the Wiener filter is 41.83702 dB, the Anisotropic filter was 36.6281 dB and the NLM filter was 33.76159 dB. The mean PSNR value of combined Wiener and NLM was 42.71564 dB, Wiener and Anisotropic was 50.33409 dB and Wiener and Median was 50.31828 dB while taking into account the combination of filters. Combined Wiener and Anisotropic filter PSNR got highest value.

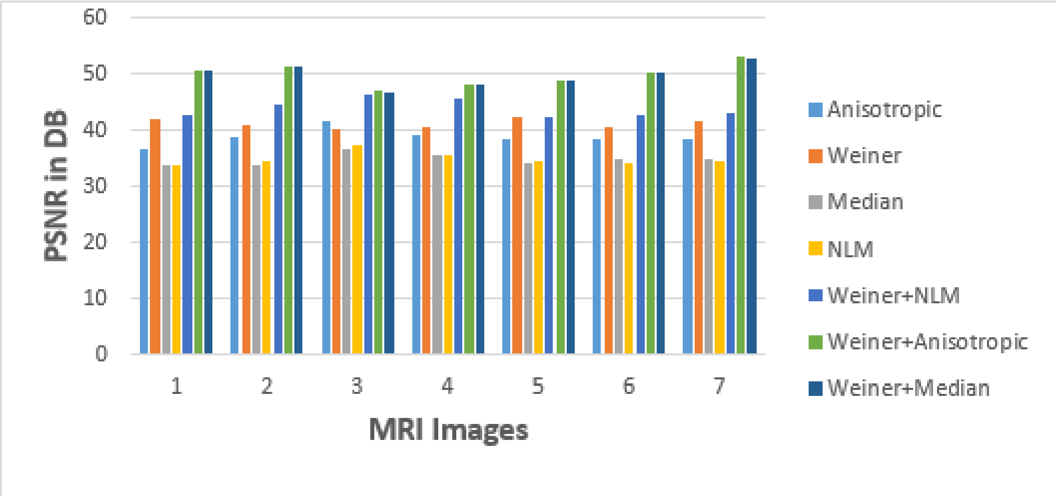

Figure 4.23 : PSNR of the DICOM Brain Images after applying Different Filtering Techniques

MSE is used to determine the mean square of errors for both the actual and intended scans. The MSE value, must be as low as possible to obtain an accurate image. Figure 4.24 shows the MSE for each unique filter and combined filters for seven distinct cases. The Median filter had a mean MSE value of 28.82616, Wiener filter of 4.29316, Anisotropic filter of 14.26918 and NLM filter of 27.56265. The mean MSE of the combined Wiener and NLM was 3.50684, Wiener and Anisotropic was 0.60684, and Wiener and Median was 0.60905 when the combination of filters was taken into account. Combined Wiener and Anisotropic filter MSE got lowest value.

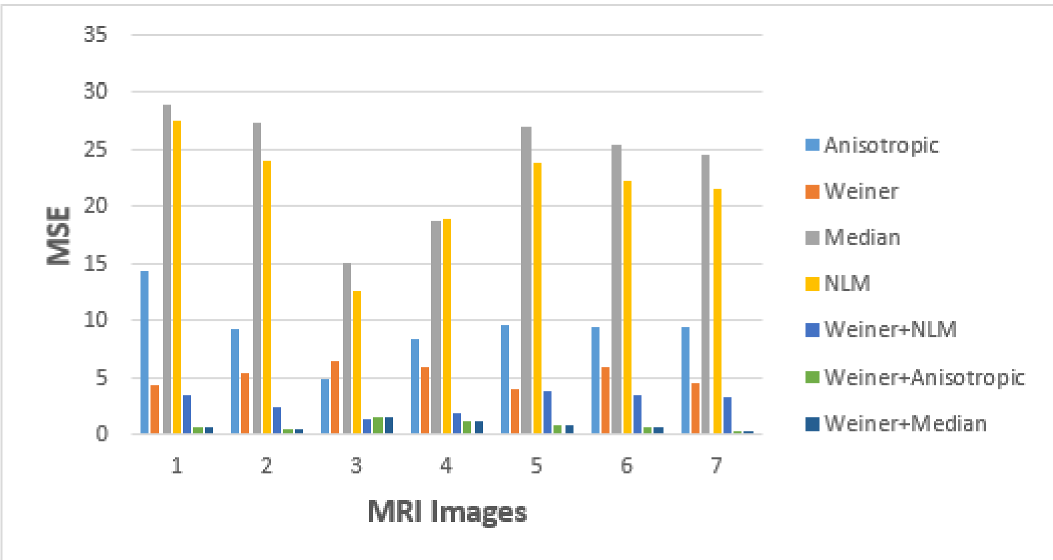

Figure 4.24 : MSE of the DICOM Brain Images after applying Different Filtering Techniques

It is common procedure to quantify inconsistency using the Root Mean Squared Error and must be kept to a low to ensure good output. Figure 4.25 shows the RMSE for each unique filter and combined filters for seven distinct cases. The mean RMSE value of the Median filter, Wiener filter, Anisotropic filter and NLM filter was 5.369, 2.0719, 3.77746 and 5.25001, respectively. Combined Wiener and NLM had mean RMSE value 1.87265, Wiener and Anisotropic had mean RMSE value 0.779, and Wiener and Median had mean RMSE value 0.78041 when the combination of filters is taken into account. Combined Wiener and Anisotropic filter RMSE got lowest value.

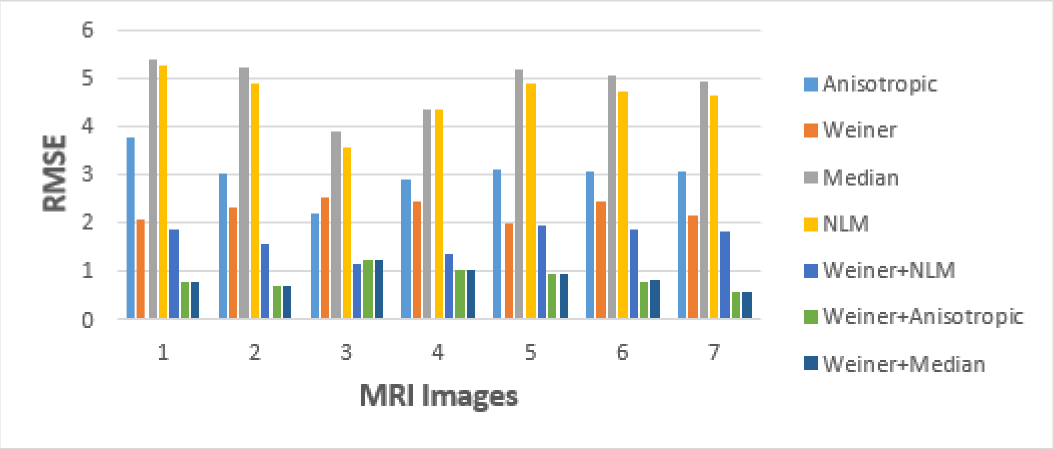

Figure 4.25 : RMSE of the DICOM Brain Images after applying Different Filtering Techniques

The Universal Image Quality Index of the filter is evaluated and is ought to be higher for improved noise - reducing quality. UQI values of the single filter and combined filters for seven separate cases is shown in Figure 4.26. The mean UQI values of the Median Filter, Wiener Filter, Anisotropic Filter and NLM Filter was 0.55756, 0.76749, 0.77565 and 0.52635 respectively. The mean UQI result of combined Wiener and NLM was 0.75576, Wiener and Anisotropic was 0.81949, and Wiener and Median was 0.77949 when the combination of filters was taken into account. Combined Wiener and Anisotropic filter UQI got highest value.

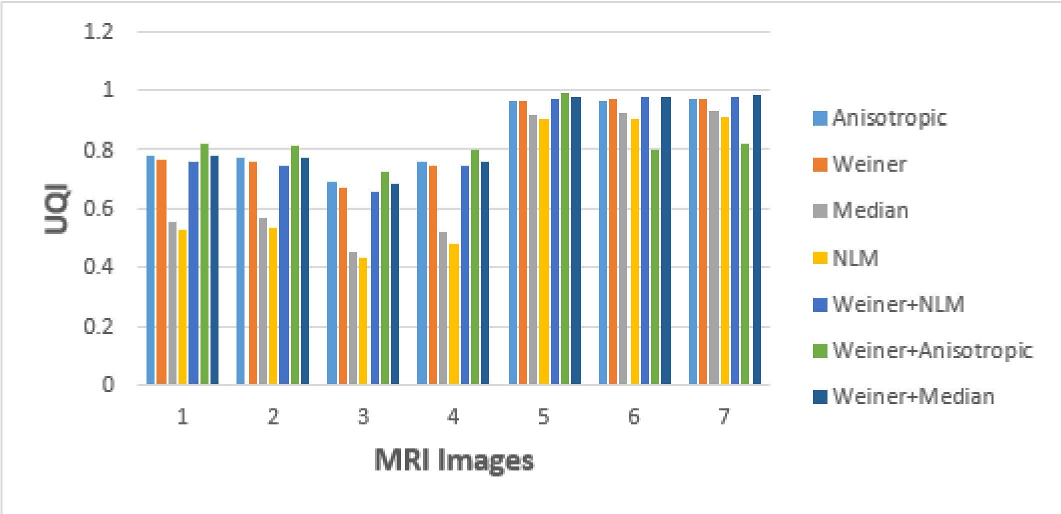

Figure 4.26 : UQI of the DICOM Brain Images after applying Different Filtering Techniques

4.3 SEGMENTATION OF THE BRAIN MRI IMAGES

From the pre-processing part combined wiener and anisotropic filter gives better results compare to all other filters. So image segmentation is applied on combined wiener and anisotropic filtered image. Four types of different image segmentation techniques are applied on various MRI filtered images. In the four different image segmentation techniques, first Cuckoo Search algorithm using Otsu as an objective function, second Cuckoo Search algorithm using Kapur entropy as an objective function, third Cuckoo Search algorithm using Tsallis entropy as an objective function and proposed method Cuckoo Search algorithm using combined Otsu and Tsallis entropy as an objective function. Figure 4.27 to Figure 4.42 shows the image segmentation results. From that proposed method gives better results compare to other techniques.

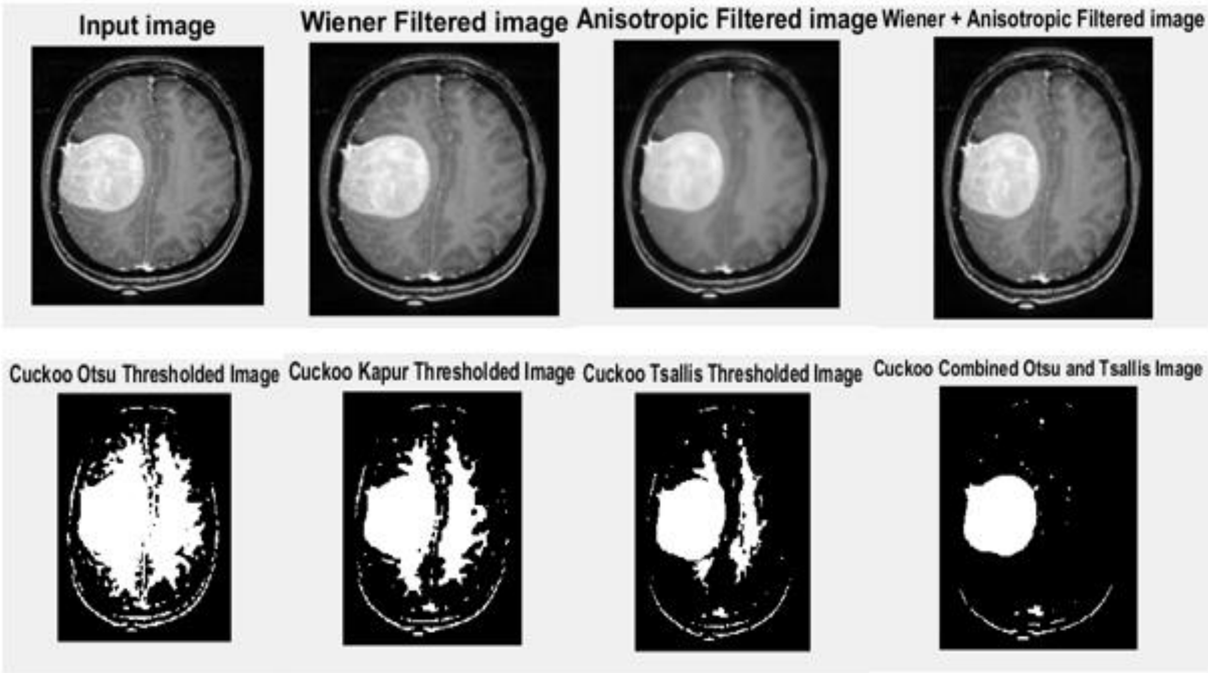

Figure 4.27 : Pictorial Presentation of Filtered output and Segmentation output of Cuckoo Otsu Threshold, Cuckoo Kapur Entropy Threshold, Cuckoo Tsallis Threshold, Cuckoo combined Otsu and Tsallis Threshold for T1 weighted Image-1

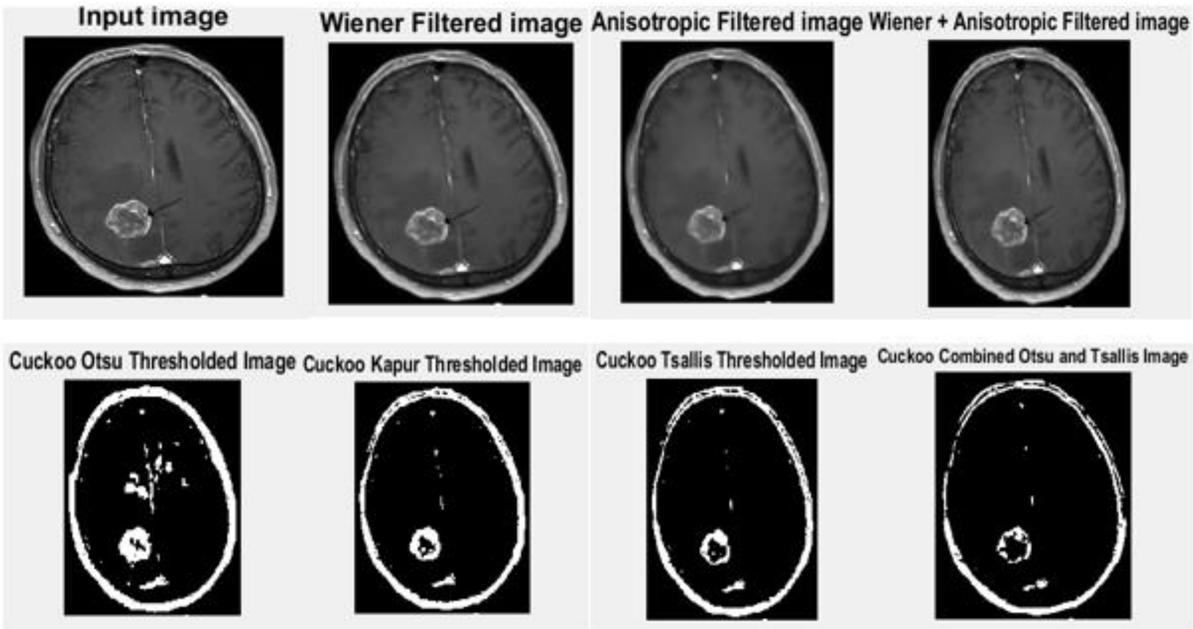

Figure 4.28 : Pictorial Presentation of Filtered output and Segmentation output of Cuckoo Otsu Threshold, Cuckoo Kapur Entropy Threshold, Cuckoo Tsallis Threshold, Cuckoo combined Otsu and Tsallis Threshold for T1 weighted Image-2

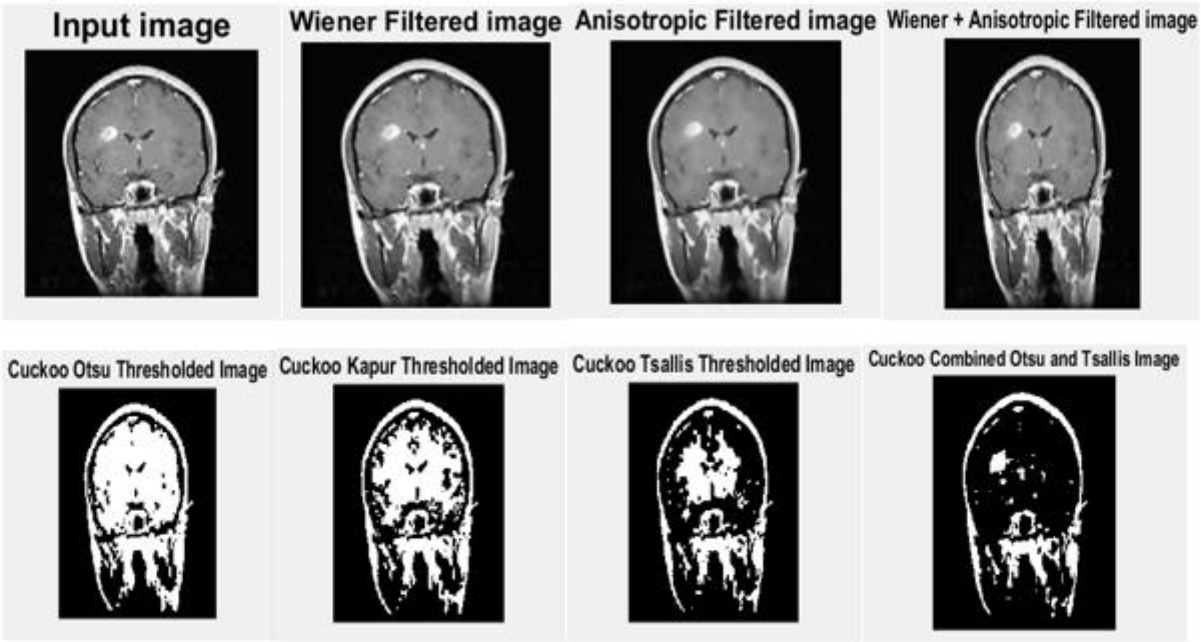

Figure 4.29 : Pictorial Presentation of Filtered output and Segmentation output of Cuckoo Otsu Threshold, Cuckoo Kapur Entropy Threshold, Cuckoo Tsallis Threshold, Cuckoo combined Otsu and Tsallis Threshold for T1 weighted Image-3

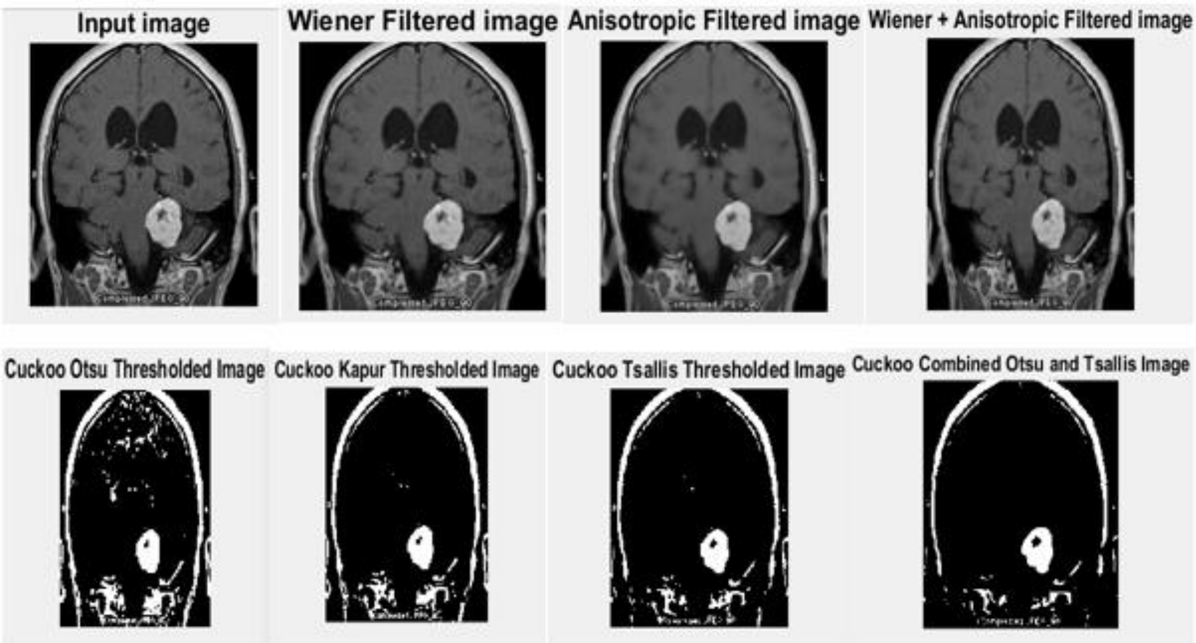

Figure 4.30 : Pictorial Presentation of Filtered output and Segmentation output of Cuckoo Otsu Threshold, Cuckoo Kapur Entropy Threshold, Cuckoo Tsallis Threshold, Cuckoo combined Otsu and Tsallis Threshold for T1 weighted Image-4

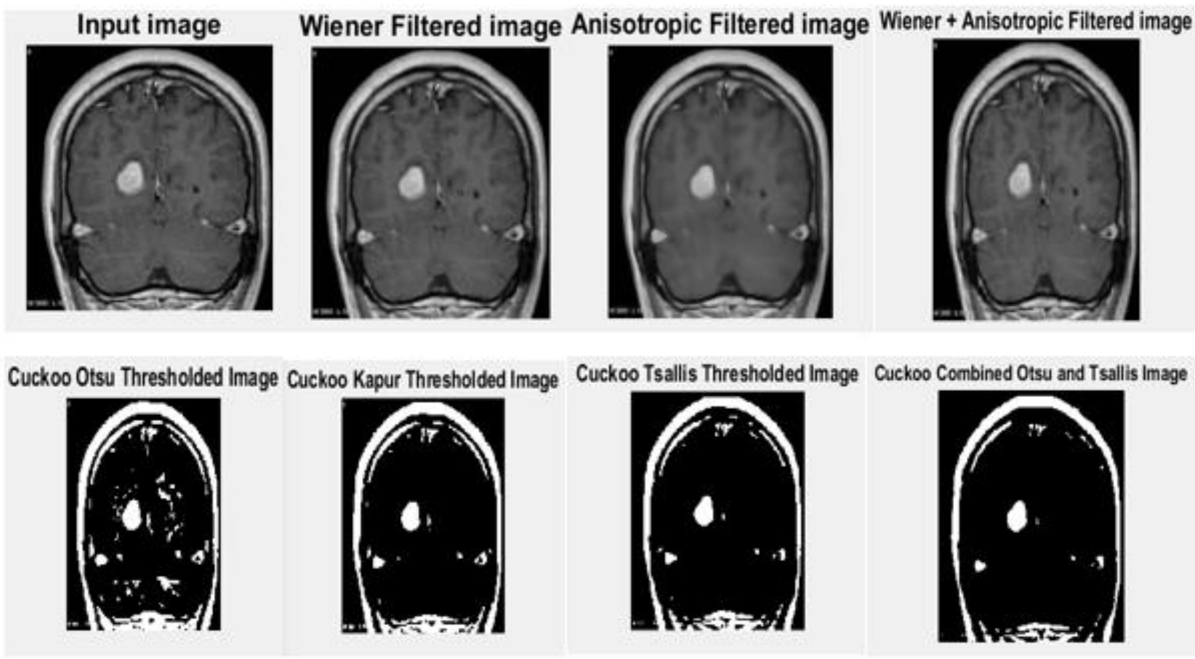

Figure 4.31 : Pictorial Presentation of Filtered output and Segmentation output of Cuckoo Otsu Threshold, Cuckoo Kapur Entropy Threshold, Cuckoo Tsallis Threshold, Cuckoo combined Otsu and Tsallis Threshold for T1 weighted Image-5

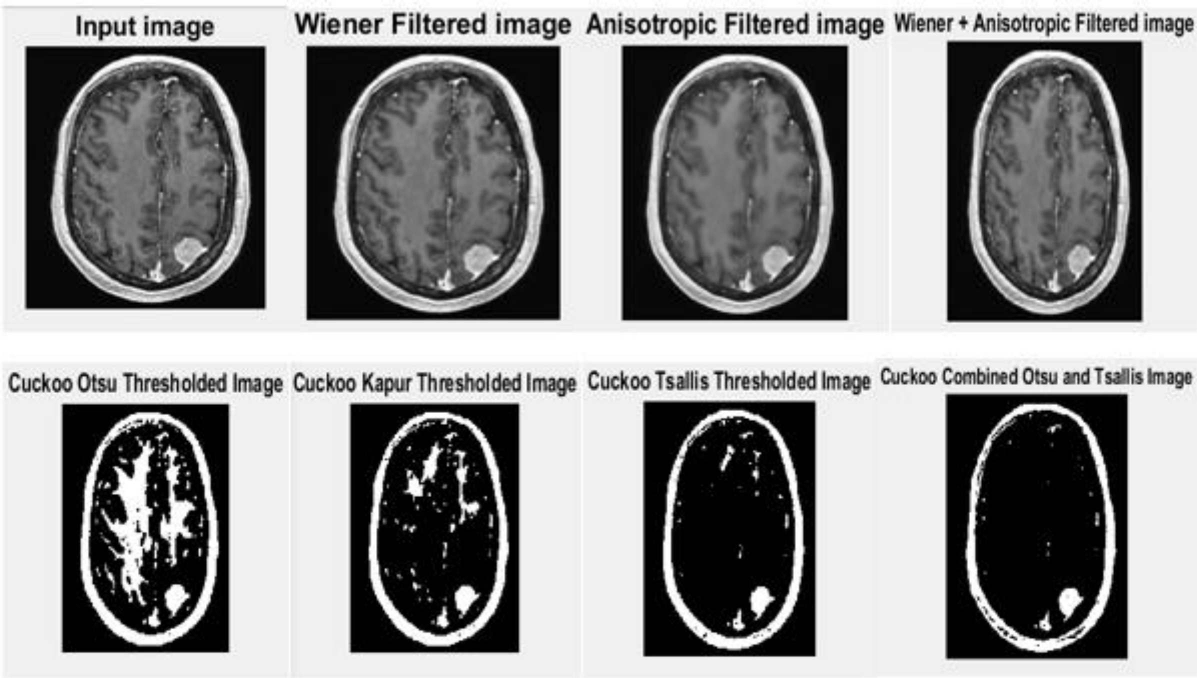

Figure 4.32 : Pictorial Presentation of Filtered output and Segmentation output of Cuckoo Otsu Threshold, Cuckoo Kapur Entropy Threshold, Cuckoo Tsallis Threshold, Cuckoo combined Otsu and Tsallis Threshold for T1 weighted Image-6

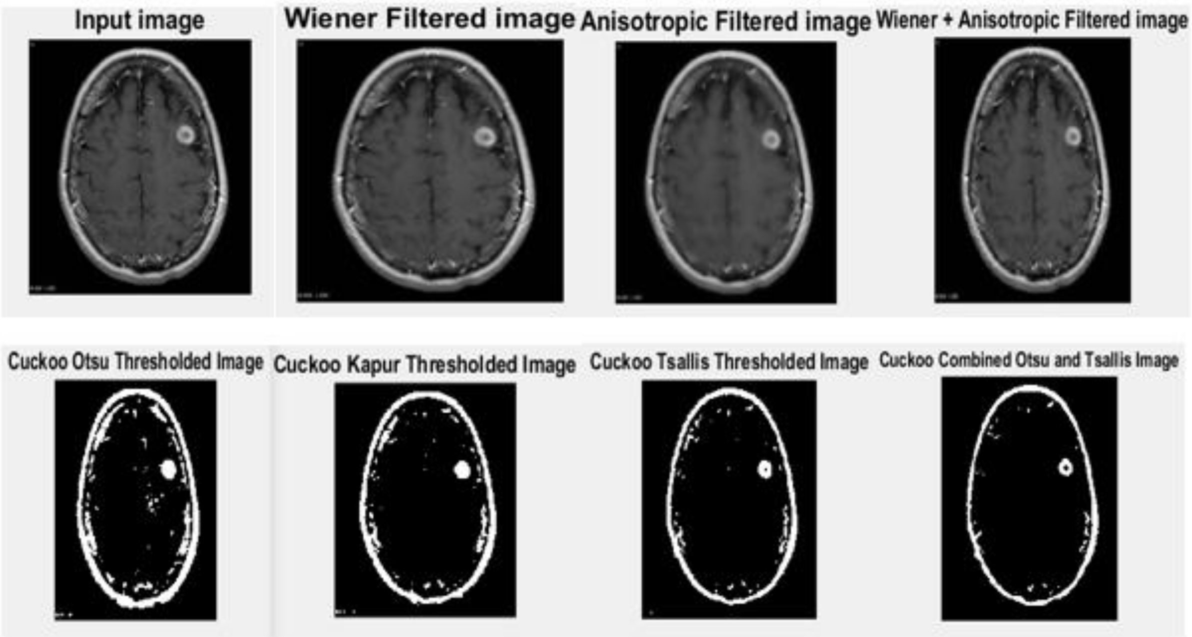

Figure 4.33 : Pictorial Presentation of Filtered output and Segmentation output of Cuckoo Otsu Threshold, Cuckoo Kapur Entropy Threshold, Cuckoo Tsallis Threshold, Cuckoo combined Otsu and Tsallis Threshold for T1 weighted Image-7

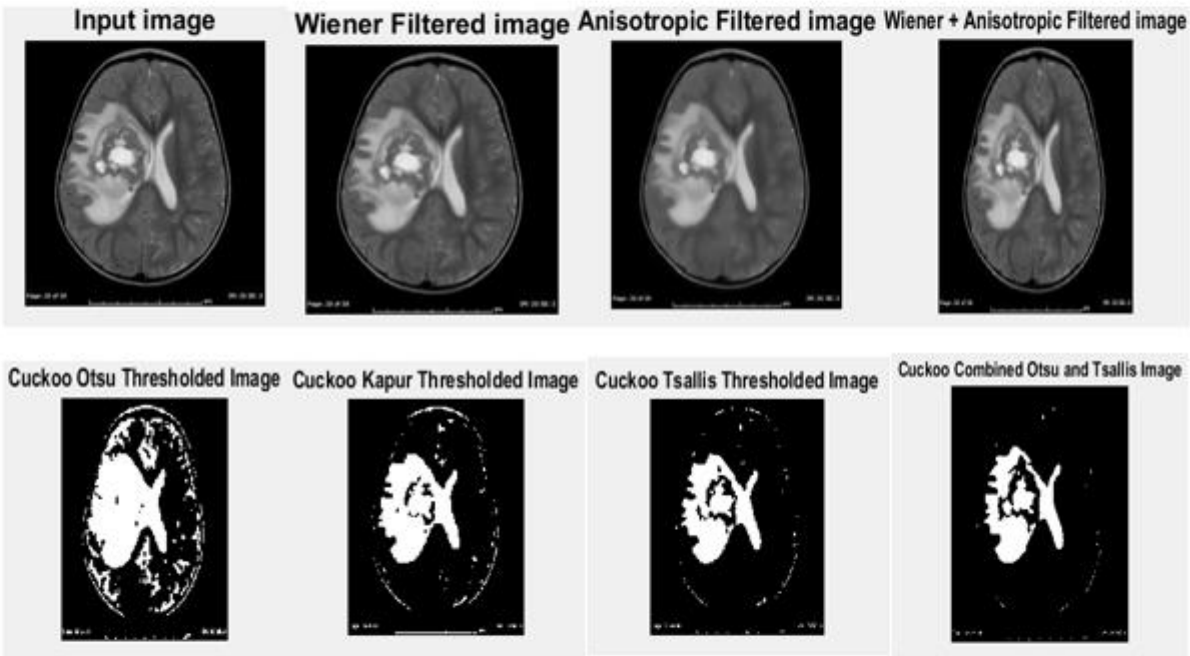

Figure 4.34 : Pictorial Presentation of Filtered output and Segmentation output of Cuckoo Otsu Threshold, Cuckoo Kapur Entropy Threshold, Cuckoo Tsallis Threshold, Cuckoo combined Otsu and Tsallis Threshold for T2 weighted Image-8

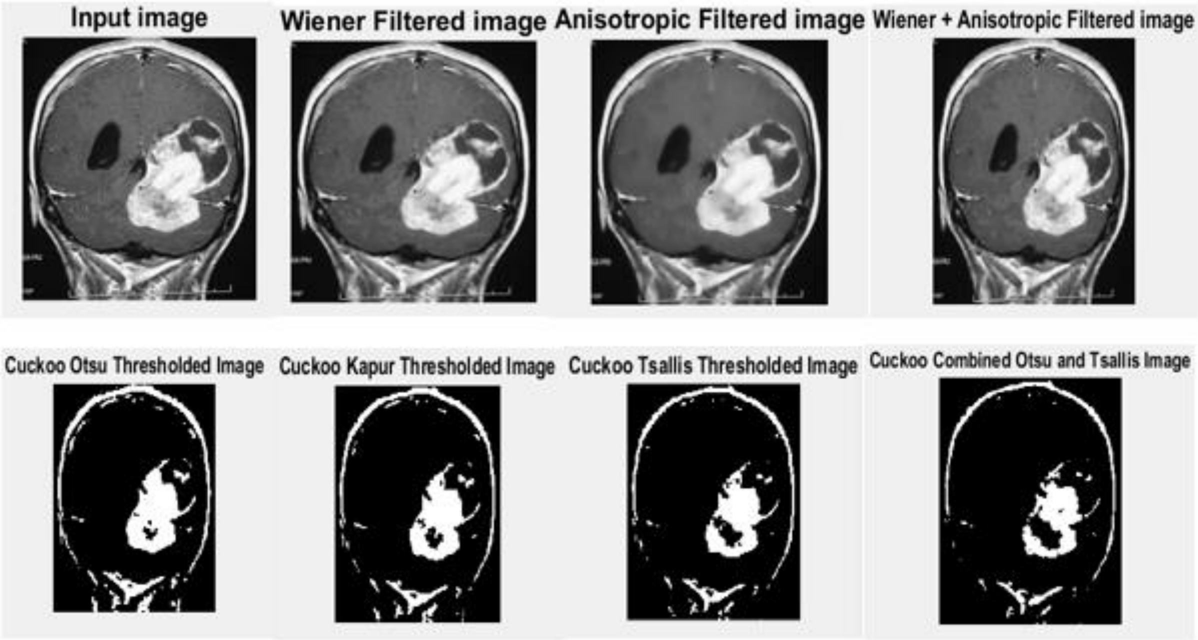

Figure 4.35 : Pictorial Presentation of Filtered output and Segmentation output of Cuckoo Otsu Threshold, Cuckoo Kapur Entropy Threshold, Cuckoo Tsallis Threshold, Cuckoo combined Otsu and Tsallis Threshold for T1 weighted Image-9

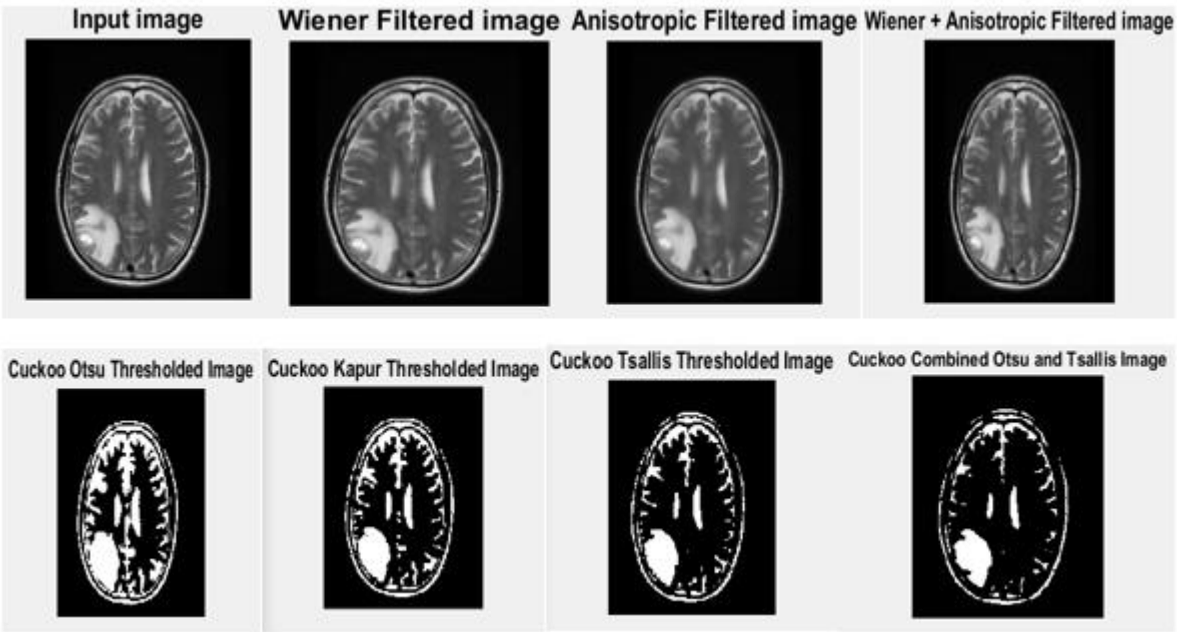

Figure 4.36 : Pictorial Presentation of Filtered output and Segmentation output of Cuckoo Otsu Threshold, Cuckoo Kapur Entropy Threshold, Cuckoo Tsallis Threshold, Cuckoo combined Otsu and Tsallis Threshold for T2 weighted Image-10

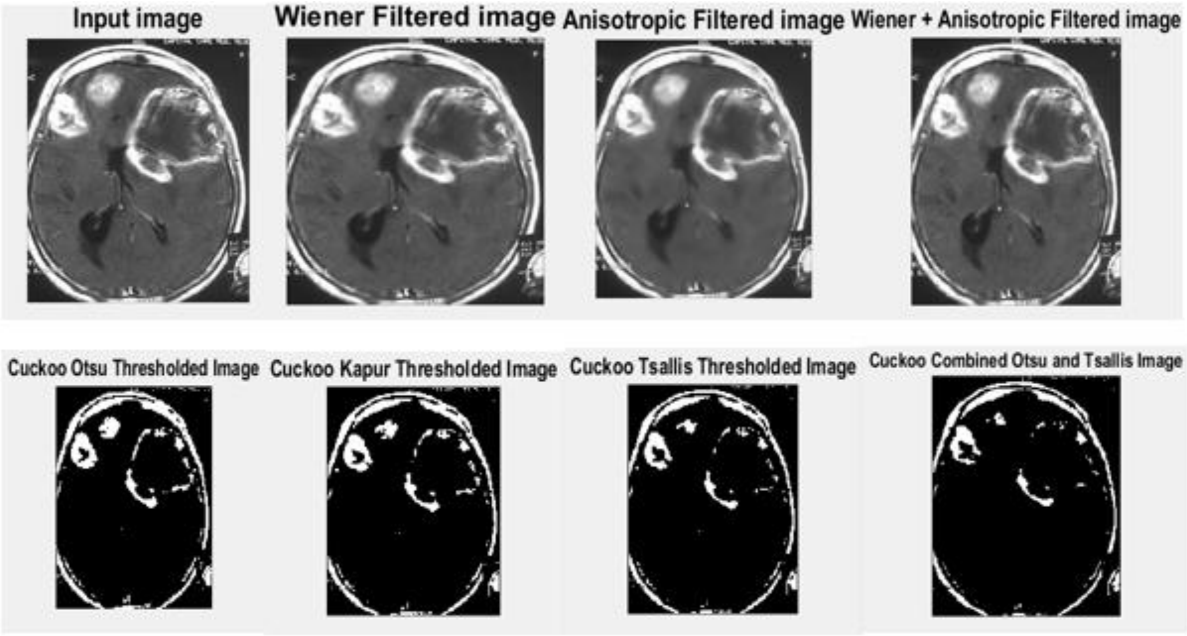

Figure 4.37 : Pictorial Presentation of Filtered output and Segmentation output of Cuckoo Otsu Threshold, Cuckoo Kapur Entropy Threshold, Cuckoo Tsallis Threshold, Cuckoo combined Otsu and Tsallis Threshold for T1 weighted Image-11

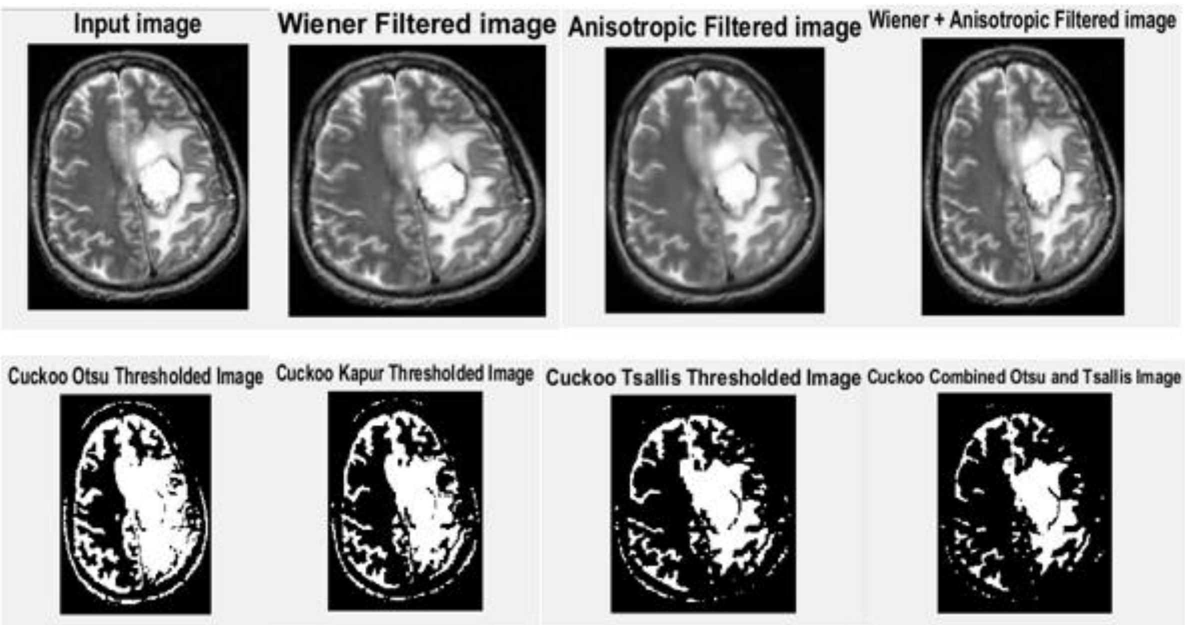

Figure 4.38 : Pictorial Presentation of Filtered output and Segmentation output of Cuckoo Otsu Threshold, Cuckoo Kapur Entropy Threshold, Cuckoo Tsallis Threshold, Cuckoo combined Otsu and Tsallis Threshold for T2 weighted Image-12

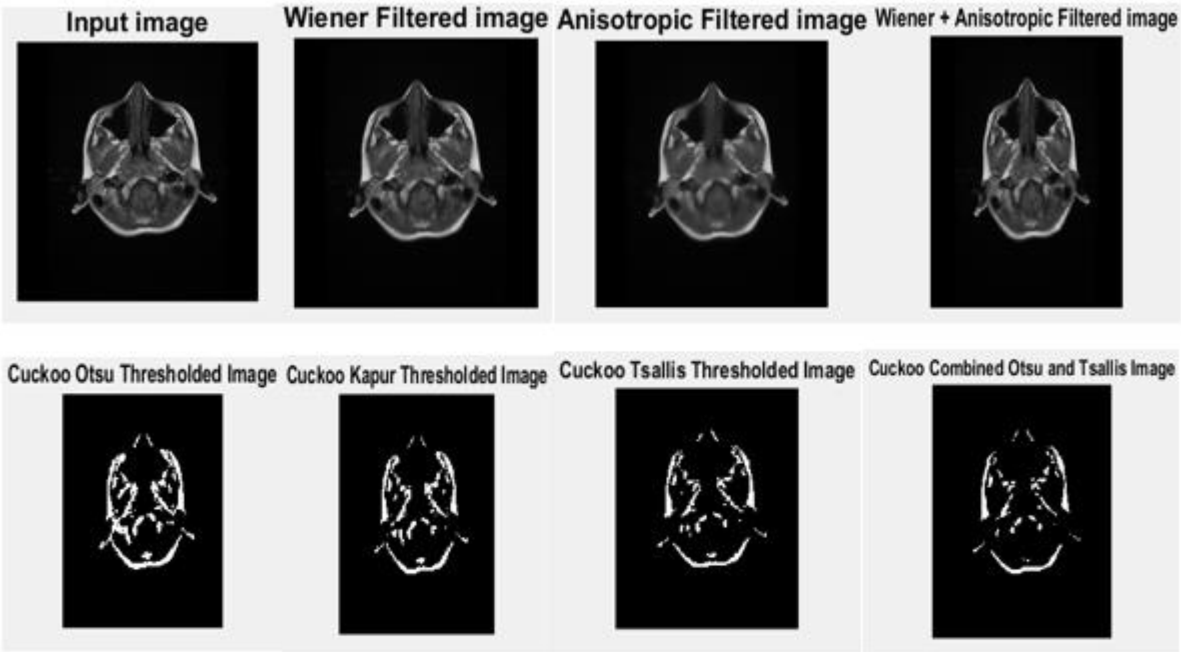

Figure 4.39 : Pictorial Presentation of Filtered output and Segmentation output of Cuckoo Otsu Threshold, Cuckoo Kapur Entropy Threshold, Cuckoo Tsallis Threshold, Cuckoo combined Otsu and Tsallis Threshold for T1 weighted Image-13

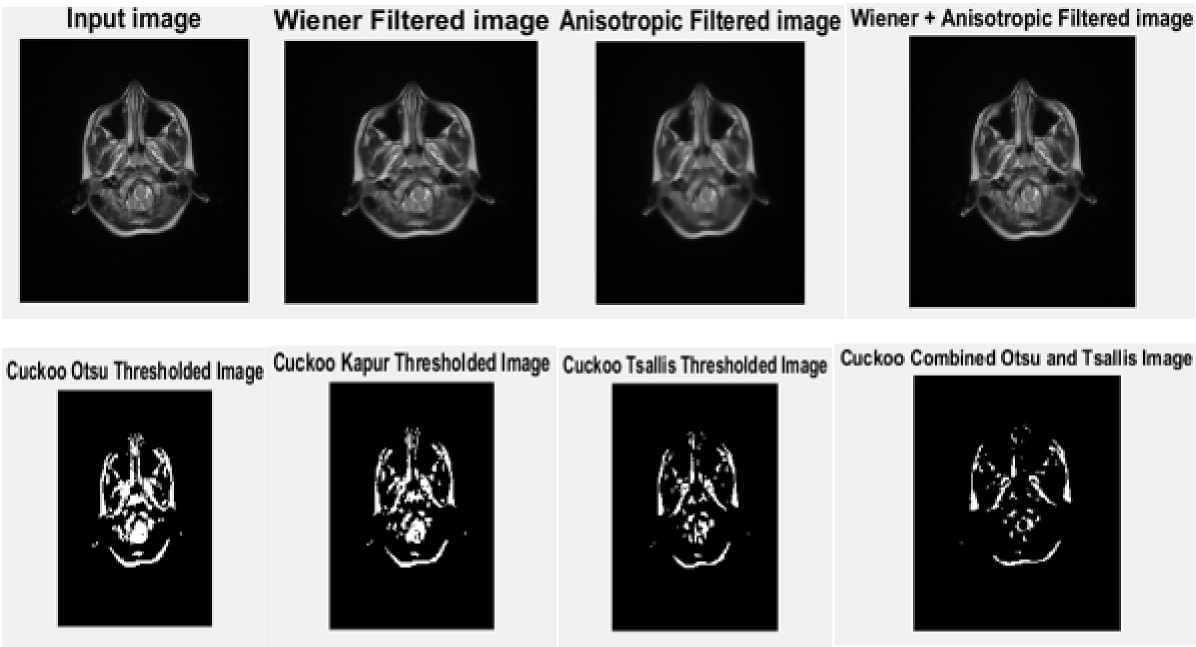

Figure 4.40 : Pictorial Presentation of Filtered output and Segmentation output of Cuckoo Otsu Threshold, Cuckoo Kapur Entropy Threshold, Cuckoo Tsallis Threshold, Cuckoo combined Otsu and Tsallis Threshold for T2 weighted Image-14

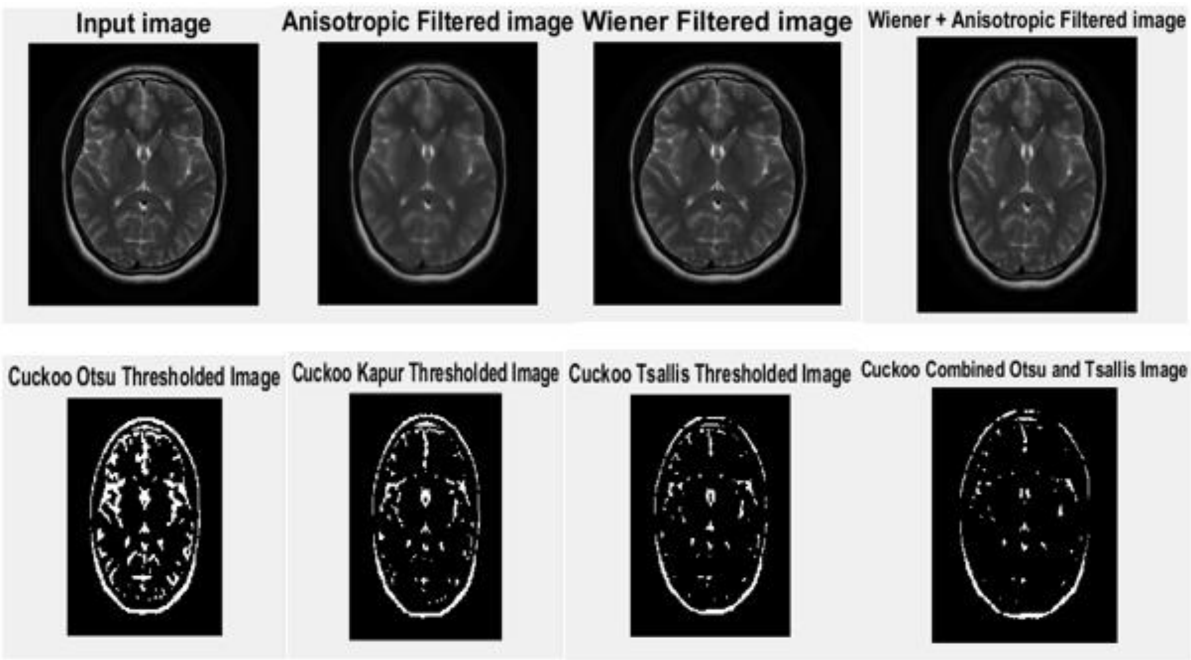

Figure 4.41 : Pictorial Presentation of Filtered output and Segmentation output of Cuckoo Otsu Threshold, Cuckoo Kapur Entropy Threshold, Cuckoo Tsallis Threshold, Cuckoo combined Otsu and Tsallis Threshold for T2 weighted Image-15

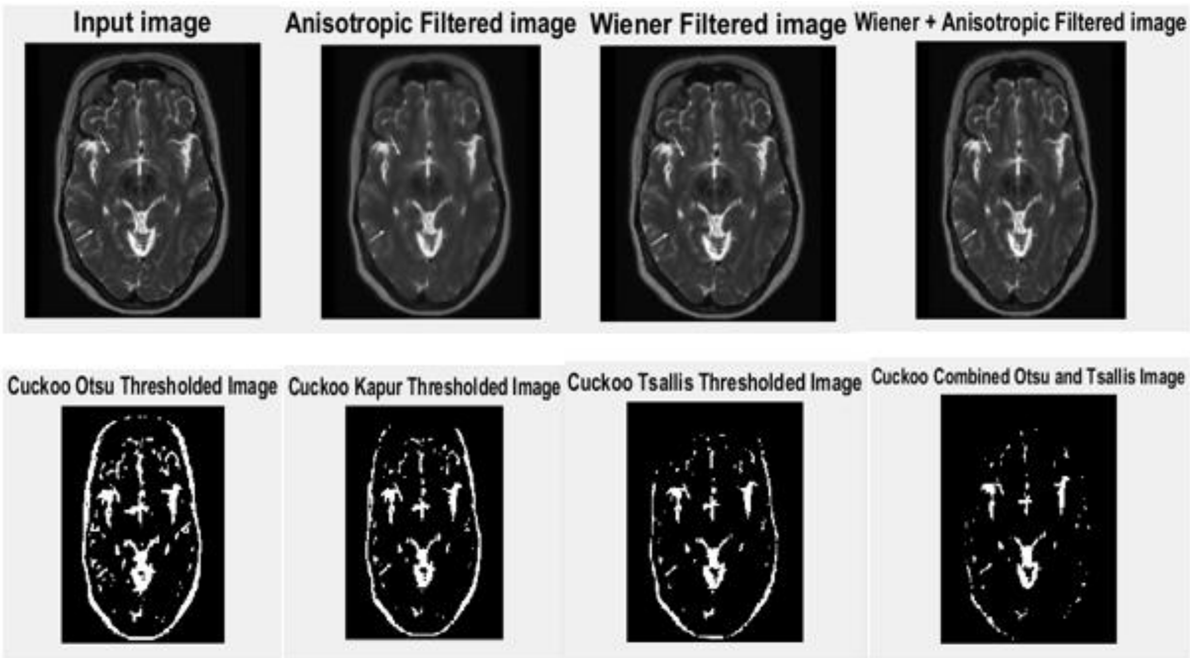

Figure 4.42 : Pictorial Presentation of Filtered output and Segmentation output of Cuckoo Otsu Threshold, Cuckoo Kapur Entropy Threshold, Cuckoo Tsallis Threshold, Cuckoo combined Otsu and Tsallis Threshold for T2 weighted Image-16

4.4 CONCLUSION

The study covers different stages of the processing such as image acquisition, pre-processing, segmentation, feature extraction, and feature classification. Pre-processing filtering techniques such as Weiner, Anisotropic, Median, Non Local Means, and different hybrid techniques explored to determine the optimal approach. Different qualitative parameters like Peak Signal to Noise Ratio, Mean Square Error, Root Mean Square Error and Universal Quality Index; are analysed. Analysis shows that combine wiener and anisotropic filter gives the better result compared to other filters implemented. With above conclusion, Weiner and Anisotropic filter is used for further processing and segmentation. In the Segmentation part, Multilevel thresholding Segmentation technique such as Cuckoo Search algorithm using different objective functions – Otsu’s, Kapur Entropy, Tsallis Entropy, Combined Otsu’s and Tsallis- are implemented and analyzed to determine their effectiveness in detecting and classifying brain tumors. In Segmentation part Cuckoo search algorithm using Combined Otsu’s and Tsallis objective function gives the better result compared to other segmentation techniques implemented.