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   RESULTS & DISCUSSION

   FINDINGS

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CONTRIBUTIONS TO BOOKS

- Sharma T., Kwatra, G. (2008) Effectiveness of Social Advertising: A Study of Selected Campaigns, Corporate Social Responsibility, Edited by David Crowther & Nicholas Capaldi, Ashgate Research Companion to Corporate Social Responsibility, Chapter 15, pp 287-303.

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- Schemenner, R.W., Huber, J.C. and Cook, R.L. (1987), "Geographic Differences and the Location of New Manufacturing Facilities," Journal of Urban Economics, Vol. 21, No. 1, pp. 83-104.

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PRE-PROCESSING AND ENHANCEMENT OF BRAIN MAGNETIC RESONANCE IMAGE (MRI)

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ABSTRACT

This proposed system for pre-processing and enhancement through Magnetic Resonance Image (MRI) is a gradient based image enhancement method and is based on the first derivative, local statistics. The Proposed enhancement method consists of four processing stages. In the first stage, the MRI brain image is acquired from MRI brain data set to MATLAB 7.1. After acquisition the MRI is given to the preprocessing stage, here the film artifacts (labels) are removed. In the third stage, the high frequency components and noise are removed from MRI using the following filters. Such as Median filter, Weighted Median filter, Adaptive filter and Spatial filter. The performance of above filters are measured and evaluated. Finally the best filter is identified and used for MR brain image enhancement.

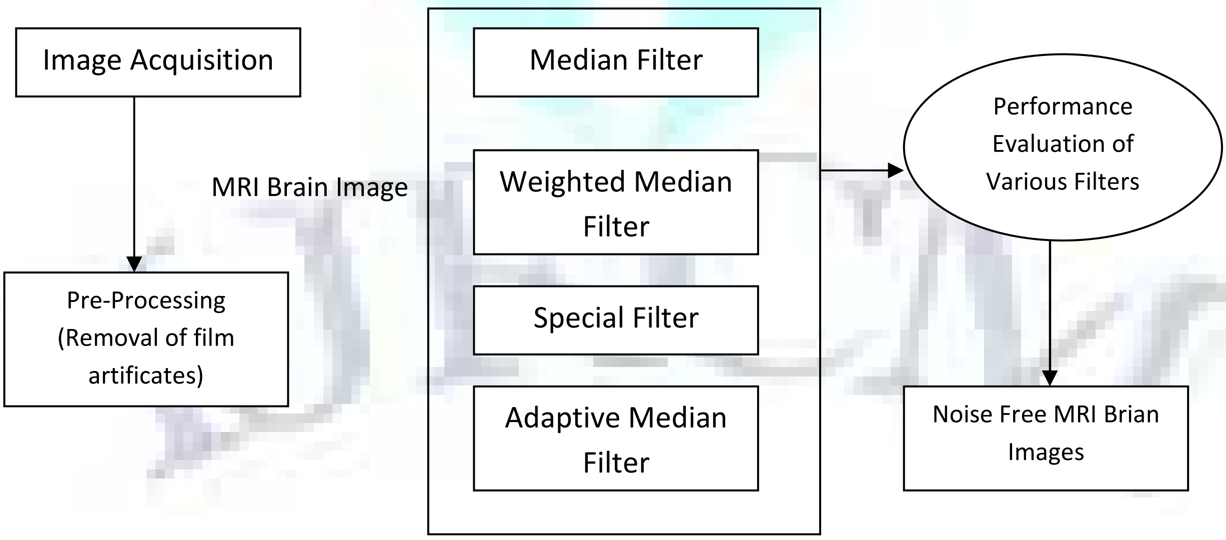
KEYWORDS

Magnetic Resonance Image (MRI), Image Acquisition, Pre-processing, Enhancement, Median filter, weighted Median filter, Spatial filter, Adaptive filter, performance Analysis.

1. INTRODUCTION

Brain tumor is one of the major causes for the increase in Mortality among children and adults. A tumor is a mass of tissue that grows out of control of the normal forces that regulate growth. The complex brain tumors can be separated into two general categories depending on the tumors origin, their growth pattern and malignancy.Primary brain tumors are tumors that arise from cells in the brain or from the covering of the brain. A secondary or metastatic brain tumor occurs when cancer cells spread to the brain from a primary cancer in another part of the body. Most Research in developed countries show that the number of people who having brain tumors and die from them has increased perhaps as much as 300 over past three decades. The National Brain Tumor Foundation (NBTF) for research in United States estimates that 29,000 people in the U.S are diagnosed with primary brain tumors each year, and nearly 13,000 people die. In children, brain tumors are the cause of one quarter of all cancer deaths. The overall annual incidence of primary brain tumors in the U.S is 11 to 12 per 100,000 people for primary malignant brain tumors, that rate is 6 to 7 per 1,00,000. In the UK, over 4,200 people are diagnosed with a brain tumor every year (2007 estimates). There are about 200 other types of tumors diagnosed in UK each year. About 16 out of every 1,000 cancers diagnosed in the UK are in the brain (or 1.6%). In India, totally 80,271 people are affected by various types of tumor (2007 estimates). NBTF reported highest rate of primary malignant brain tumor occurred in Northern Europe, United States and Israel. Lowest rate arised in India and Philippines. At present in medical world lot of brain tumor detection systems are available. This paper describes overall information about preprocessing and enhancement of automatic system with high efficiency and accuracy than existing systems.

FIGURE 1: THE OVERVIEW OF AUTOMATIC SYSTEM



2. OVERVIEW OF AUTOMATIC SYSTEM

This Automatic system proposes a gradient-based image enhancement method in order to improve the image quality and visibility of low-contrast features while suppressing the noises. Image enhancement is the improvement of image quality without knowledge about the source of degradation. The enhancement methods can be dividing into indirect and direct method. In direct method is to find the contrast of the image and then enhance the contract. But the indirect method is not defining the contrast. The algorithm of contrast is based on global information or local information or both of local and global information [29]. The major problem with the contrast enhancement algorithms is that for an image, some regions may be under-enhanced while some regions may be over-enhanced. Mainly image enhancement includes intensity and contrast manipulation, noise reduction, background removal, edges Sharpening, filtering etc. The above Figure 1 shows the overview of the automatic system.

The advantage of this automatic system is it explains the gradient-based image enhancement method with high range of efficiency and accuracy. It performs four steps namely Image Acquisition, Preprocessing, Enhancement and Performance Analysis. In image acquisition step, MRI brain image is acquired from brain dataset to MATLAB 7.0. Secondly, the film artifacts on the MRI are removed in preprocessing. Artifacts like name, age, date of birth of the patient. third step of automatic system is enhancement use to remove noise, high frequency components, and unwanted region of brain MRI through enhancement filters. We are using an efficient tracking algorithm to remove film artifacts. Finally the performance of median, weighted median, Adaptive and spatial filters are measured and evaluated.

3. EXISTING METHODS FOR ENHANCEMENT

Image enhancement is the improvement of digital image quality without knowledge about the source of degradation. The enhancement methods can be dividing into indirect and direct method. In direct method is to find the contrast of the image and then enhance the contract. But the indirect method is not defining the contrast. The algorithm of contrast is based on global information or local information or both of local and global information [29]. The major problem with the contrast enhancement algorithms is that for an image, some regions may be under-enhanced while some regions may be over-enhanced. Mainly image enhancement includes intensity and contrast manipulation, noise reduction, background removal, edges Sharpening, filtering etc. Now lot of methods and techniques are available for enhancement.Table1 shows the existing enhancement techniques in the recent years of research.

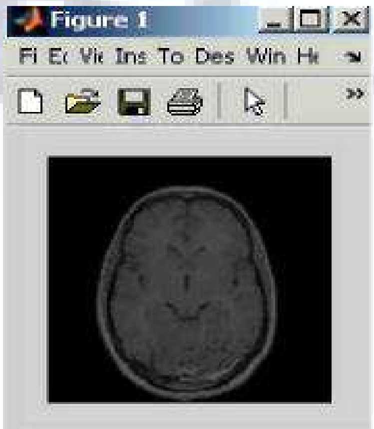
TABLE 1: ENHANCEMENT TECHNIQUES

Authors	Methods
Ladan et al..[18]	Prewitt edge-finding filter.
M.Karnan et. al.[29]	Median Filter, Gradient Based Method.
Gray [12]	Genetic Algorithm
Chunyan et al.,[6]	Triple Quantum Filtered Sodium MRI (TQF) Technique.
Tsai et al.,[30]	Low pass Filter.
Boada et al.,[4]	Triple Quantum Filtered (TQF) Sodium NMR, Novel image Approach.
Marcel Prastawa et al.,[20]	Anisotropic Diffusion.
Ladan et al.,[18]	Edge Finding filter, Morphological operation.
Aria et al.,[2]	Gadolinium-Diethylenetriaminepentaacetic acid (Gd-TPA) Enhancement.
Amini et al.,[1]	Prewitt edge-finding filter.
Zhe chen et al.,[34]	Morphological Filter.
Xiao et al.,[32]	Gabor Filter.
Corina et al.,[7]	Gaussian Filter.
Dimitris et al.,[9]	Gabor Filter Bank technique.
Hideki et al.,[14]	V-filter.
Gordon et al.,[13]	Anisotropic sample.
ShiShir et al.,[27]	Nonlinear Filter.
Salman et al.,[25]	Region Growing Filter.
Sean et al.,[26]	K-nearest neighbour Algorithm.

4. IMAGE ACQUISITION

To Access the real medical images like MRI, PET (Positron Emission Tomography) or CT (Computer Tomography) scan and to take up a research is a very complex because of privacy issues and heavy technical hurdles. . MRI Images were transformed to a Linux Network through LAN (Local Area Network) Kovai Medical Center Hospital (KMCH) India. All images had 1 mm slice thickness with 1×1 mm in plane resolution. Among this automatic systems, the 0.5T intra-operative Magnetic Resonance Scanner of the Kovai Medical Center and Hospital (KMCH, Signa SP, GE Medical Systems) offers the possibility to acquire 256×256×58(0.86mm, 0.86mm, 2.5 mm) T1 weighted images with the fast spin echo protocol (TR=400, TE=16 ms, FOV=220*220 mm) in 3 minutes and 40 seconds. The quality of every 256 ×256 slice acquired intra-operatively is fairly similar to images acquired with a 1.5T Conventional Scanner, but the major drawback of intra-operative image is that slice remains thick (2.5 mm).The following figure2 shows the example of image acquisition through MATLAB.The images we got from MRI are of four type of views such as Top view of brain MRI, Bottom view, Side view and Front view. But here we are using front view of brain image with the age from 20 to 50.

FIGURE 2: THE ORIGINAL MR IMAGE FROM MAT LAB7.0



MRI provides detailed pictures of brain and nerve tissues in multiple planes without obstruction by overlying bones. Brain MRI is the procedure of choice for most brain disorders. It provides clear images of the brainstem and posterior brain, which are difficult to view on a CT scan.

5. PRE-PROCESSING

Preprocessing functions involve those operations that are normally required prior to the main data analysis and extraction of information, and are generally grouped as radiometric or geometric corrections. Radiometric corrections include correcting the data for sensor irregularities and unwanted sensor or atmospheric noise, removal of non-brain voxels and converting the data so they accurately represent the reflected or emitted radiation measured by the sensor.

The Preprocessing aspects are surveyed and analyzed in this section. The Preprocessing Techniques such as Content Based model, Fiber tracking Method, Wavelets & Wavelet Packets, and Fourier transform technique [15; 23; 3; 17]. Olivier et al. designed a new Standard Imaging Protocol for brain tumor radiotherapy. MRI has been acquired in the standard follow up after surgical resection [22]. Dana et al presented statistical parametric mapping implementation and pipeline approach for registration and resampling stages. The pipeline consists of noise reduction and inter-slice intensity variation correction [8]. Elizabeth et al explained Pixel Histograms and Morphological process for acquiring brain image from MRI. It was more robust to noise [10]. Leung et al described Boundary Detection Algorithm, Generalized Fuzzy Operator (GFO), Contour Deformable Model, and Region base technique for image processing applied in radiology for 3D reconstruction [19]. Patrick et al developed a new Boundary Model and Nonlinear matching scheme to estimate the location of the boundary points using intensity data with standardized data. Azadeh et al designed a method on Wavelets & Wavelet Packets for Noise reduction and correcting baseline [3]. Paulo proposed a method of Fiber tracking to process MR-DT1 datasets [23]. Karen et al represented a Fourier transform technique for MRI preprocessing [17]. Lorenzen et al designed a Geometric prior image registration [24]. Xin et al. presented Unseeded Region Growing (URG) Algorithm use to convert the MRI image into standard Format [33]. Zu et al, analyzed a new method on Sub-second imaging technique and histogram based technique Separate brain image from head image removal of residual fragments [35]. Brian et al, designed Principal Component for to minimize the artifacts present in the PET data set [5].Mark et al, described a new method on Statistical Parametric Mapping for spatial registration and resampling stages used the T1 single subject template and used existing implementation for the intensity normalization stages [21]. Toshiharu et al, said a Independent Component Analysis (ICA) method for separate the components in MR images into independent components (IC's).

5.1 REMOVAL OF FILM ARTIFACTS

The film artifacts are removed using tracking algorithm. Below the table2 describes the steps for tracking algorithm. This algorithm is used for efficient removal of film artifacts without disturbance of pixels on the MRI. Poor power quality is a major contributor to MRI image artifacts. Power anomalies such as spikes, surges, sags and unwanted electrical noise all contribute to the inaccurate detection, processing and display of images in MRI systems. Here, starting from the first row and first column, the intensity value of the pixels are analysed and here the threshold value of the film artifacts are found. The threshold value, greater than of threshold value is removed from MRI. The high intensity value of film artifacts are removed from MRI brain image and it's consists of salt and pepper noise occurred during the removal of film artifacts. Figure 3 shows the MRI without film artifacts

FIGURE 3 (A) THE ORIGINAL MRI IMAGE (B) MRI WITHOUT FILM-ARTIFACTS.

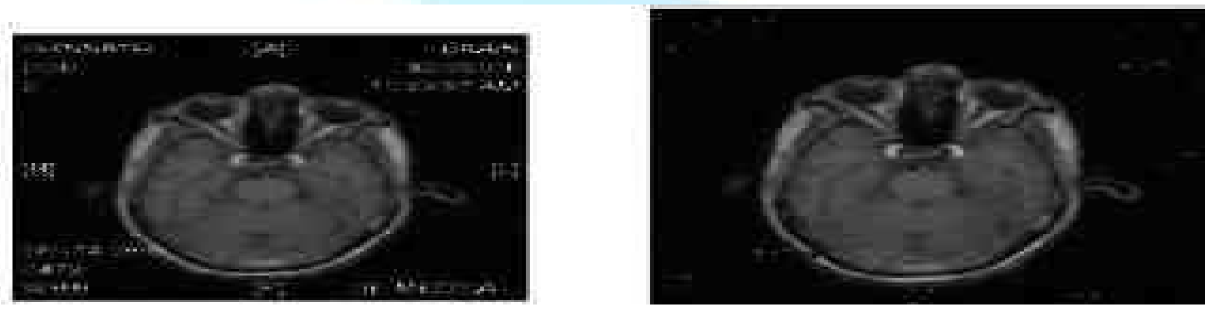


TABLE 2: THE STEPS FOR TRACKING ALGORITHM

Step 1: Read the MRI image and store it in a two dimensional matrix.
Step 2: Select the peak threshold value for removing white labels
Step 3: Set flag value to 255.
Step 4: Select pixels whose intensity Value is equal to 255.
Step 5: If the intensity value is 255 then, The flag value is set to zero and thus the Labels are removed from MRI.
Step 6: Otherwise skip to the next pixel.

6. ENHANCEMENT

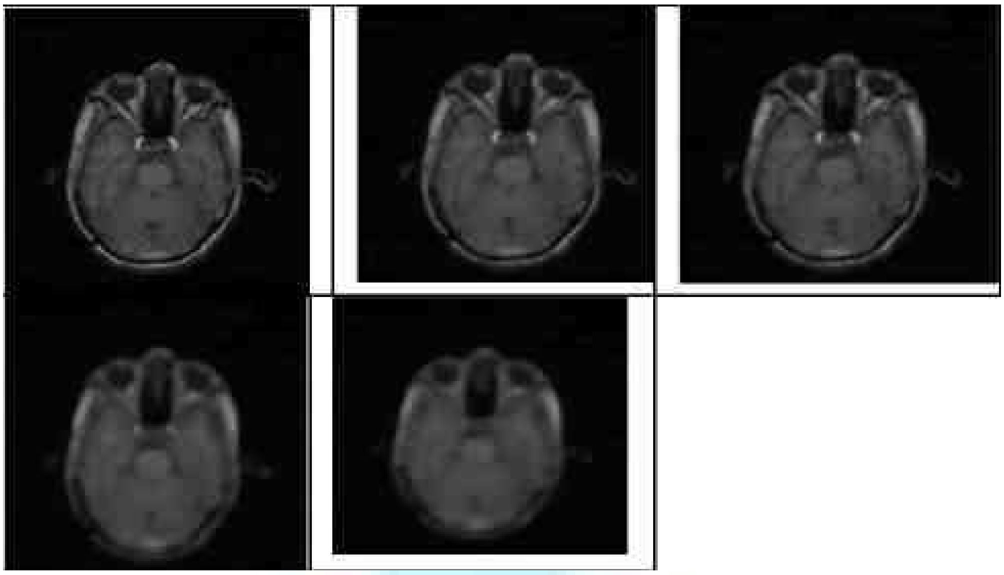
Image enhancement methods inquire about how to improve the visual appearance of images from Magnetic Resonance Image (MRI), Computed Tomography (CT) Scan, Positron Emission Tomography (PET) and the contrast enhancing brain volumes were linearly aligned. The enhancement activies are removal of film artifacts and labels, filtering the images. This part is use to enhances the smoothness towards piecewise-homogeneous region and reduces the edge-blurring effect. Conventional Enhancement techniques such as low pass filter, Median filter, Gabor Filter, Gaussian Filter, Prewitt edge-finding filter, Normalization Method are employable for this work.

The proposed system describes the information of enhancement using four types of filters such as 1.median filter 2. Weighted Median filter 3. Adaptive filter and 4. Spatial filter for removing high frequency components such as impulsive noise, salt and peper noise and high frequency components.In the Enhancement stage the filters are designed to enhance the appearance of images, primarily by sharpening Edges, corners, and line detail. Several of the new enhancement filters also incorporate a noise-reduction component.Noise is like interferences which present as a irregular granular pattern. This random variation in signal intensity degrades image information. The main source of noise in the image is the patient's body (RF emission due to thermal motion). The whole measurement chain of the MR scanner (coils, electronics...) also contributes to the noise. This noise corrupts the signal coming from the transverse magnetization variations of the intentionally excited spins (on the selected slice plane). four filters in the Enhancement phase are designed to enhance the appearance of images, primarily by sharpening edges, corners, and line detail. Several of the new enhancement filters also incorporate a noise-reduction component.

6.1 MEDIAN FILTER

In medical image processing, necessary to perform a high degree of noise reduction in an image before performing high-level processing steps. So we performed Median Filter can remove the noise, high frequency components from MRI without disturbing the edges and it is used to reduce' salt and pepper' noise. This technique calculates the median of the surrounding pixels to determine the new (denoised) value of the pixel. A median is calculated by sorting all pixel values by their size, then selecting the median value as the new value for the pixel. The amount of pixels which should be used to calculate the median.

FIGURE 4: (A) THE FILTERED MRI BRAIN IMAGE USING MEDIAN FILTER WITH 3X 3 WINDOW (B) 5X 5 WINDOW (C) 7X 7 WINDOW (D) 11X 11 WINDOW.



each pixel, an 3 x 3, 5 x 5, 7 x 7, 9 x 9, 11 x 11 window of neighbourhood pixels are extracted, and The pixel intensity values are arranged in Assending orderand the median value is calculated for that window. The intensity value of the center pixel is replaced with the median value. This procedure is done for all the pixels in the image to smoothen the edges of MRI. High Resolution Image was obtained when using 3 x 3 than 5 x 5 and so on. The below table3 shows the model of median filter.

TABLE 3: THE EXAMPLE OF MEDIAN FILTER WITH 3 X 3 WINDOWS

(a) Before filtering

42	47	52
55	64	41
47	55	66

41, 42,47 ,47 , **52,** 55,55,64,66 ----→Assending Order of pixel intensity
Median value 52

(b) After Filtering

42	47	52
55	**52**	41
47	55	66

TABLE 4: PERFORMANCE ANALYSIS OF MEDIAN FILTER WITH DIFFERENT SET OF WINDOW

Pixel size	Mean gray level of foreground	Mean gray level of Background	Contrast value
3×3	**93.154**	**4.049**	**0.9167**
5× 5	95.414	4.267	0.9144
7×7	95.475	4.305	0.9137
9 ×9	94.835	4.284	0.9136
11 ×11	93.869	4.243	0.9135

The above 3×3, 5×5, 7×7, 9×9, 11×11 windows are analysed in that 3×3 window is choose based on the high contrast than 5×5, 7×7, 9×9,and 11×11.

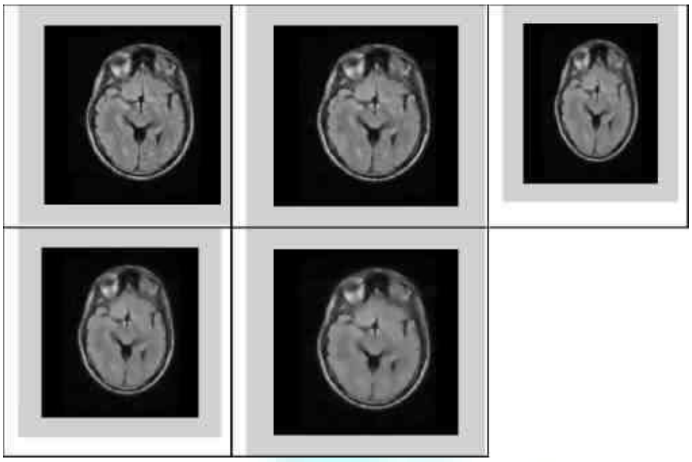
6.2 WEIGHTED MEDIAN FILTER

A weighted median filter controlled by evidence fusion is proposed for removing noise from MRI brain images with contrast. It has a great potential for being used in rank order filtering and image processing. The weights of the filter are set based on intensity value of the pixels in the MRI image. Here we used four weights such as 0, 0.1, 0.2 and 0.3. if the intensity value of the pixel is 0 then consider the weight of the pixel is 0. Else if the range of pixel intensity between 1-100 then the weight is 0.1, else if the range of pixel intensity between 101-200 then the weight is 0.2, otherwise the weight of the pixel is 0.3. the above weights are multiplied with pixel intensity .after that the median filter is applied for calculate weighted median filter. The following figure 5 shows the filtered original MR brain image using 3×3, 5×5, 7×7, 9×9, 11×11 windows.

TABLE 5: PERFORMANCE ANALYSIS OF WEIGHTED MEDIAN FILTER WITH DIFFERENT SET OF WINDOW

Pixel size	Mean gray level of foreground	Mean gray level of Background	Contrast value
3×3	88.2121	3.3551	0.9267
5× 5	**96.4823**	**3.6145**	**0.9278**
7×7	95.9038	3.6561	0.9266
9 ×9	96.1042	3.7143	0.9256
11 ×11	96.1785	3.7485	0.9250

FIGURE 5: THE FILTERED MRI BRAIN IMAGE USING WEIGHTED MEDIAN FILTER WITH 3X 3, 5X 5 , 7X 7, 9 X9 , 11X 11 WINDOW



In above table5 3×3, 5×5, 7×7, 9×9, 11×11 windows are analysed in that 5×5 window is choosed based on the high contrast than 3×3, 7×7, 9×9, and 11×11.

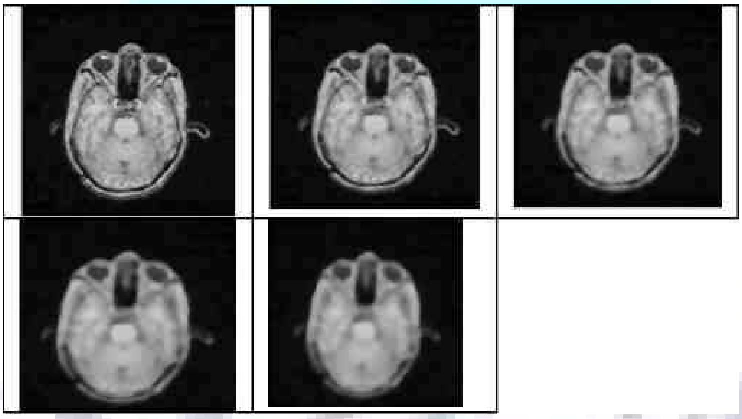
6.3 ADAPTIVE FILTER

A new type of adaptive center filter is developed for impulsive noise reduction of an image without the degradation of an original image. The image is processed using an adaptive filter. The shape of the filter basis is adapted to follow the high contrasted edges of the image. In this way, the artifacts introduced by a circularly symmetric filter at the border of high contrasted areas are reduced. The following figure 6 shows the filtered original MR brain image using 3×3, 5×5, 7×7, 9×9, 11×11 windows.

TABLE 6: PERFORMANCE ANALYSIS OF ADAPTIVE FILTER WITH DIFFERENT SET OF WINDOW

Pixel size	Mean gray level of foreground	Mean gray level of Background	Contrast value
3×3	92.5059	4.2789	0.9116
5× 5	95.1252	4.5236	0.9092
7×7	95.2662	4.5717	0.9084
9 ×9	94.1861	4.5462	0.9079
11 ×11	92.5125	4.4779	0.9077

FIGURE 6: FILTERED MRI BRAIN IMAGE USING ADAPTIVE FILTER WITH 3X 3, 5X 5, 7X 7, 11X 11



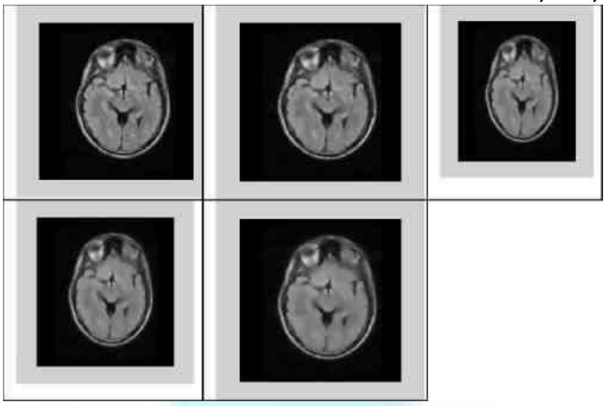
6.4 SPATIAL FILTER

A spatial filter design method is used to reduce the magnetic noise in the magnetic resonance. This filter is used to extract the external magnetic noise appearing on MRI scan image and to improve the signal-to-noise ratio of the MRI brain image. In spatial domain filtering, the filter is specified as 3D array. The kernel is then applied to the image via convolution or correlation using imfilter or filter2.Here, the filter for the picture elements includes a first filter that applies one filter function to the pixels in each column of the image. The partially filtered pixels are stored in matrix and then read row by row in a field interlaced order. The rows of picture elements are sent to a second filter that applies another filter function to each row. The fully filtered picture elements from the second filter are stored or converted to a matrix to display an image.For each pixel, an 3×3, 5×5, 7×7, 9×9, 11×11 window of neighbourhood pixels are extracted A new type of adaptive center filter is developed for impulsive noise reduction of an image without the degradation of an original image. The image is processed using an adaptive filter. The shape of the filter basis is adapted to follow the high contrasted edges of the image. In this way, the artifacts introduced by a circularly symmetric filter at the border of high contrasted areas are reduced.and the median value is calculated for that window.finally 3×3 window is selected for noise reduction based on high contrast.The following figure 7 shows the filtered original MR brain image using 3×3, 5×5, 7×7, 9×9, 11×11 windows.

TABLE 7: PERFORMANCE ANALYSIS OF SPATIAL FILTER WITH DIFFERENT SET OF WINDOW

Pixel size	Mean gray level of foreground	Mean gray level of Background	Contrast value
3×3	**92.5049**	**4.2689**	**0.9106**
5× 5	95.1232	4.5136	0.9072
7×7	95.2552	4.5617	0.9024
9 ×9	94.1851	4.5452	0.9019
11 ×11	92.5225	4.4679	0.9017

FIGURE 7: FILTERED MRI BRAIN IMAGE USING SPATIAL FILTER WITH 3X 3 , 5X 5 ,7X 7 ,11X 11



In the above table 3×3, 5×5, 7×7, 9×9, 11×11 windows are analysed in that 3×3 window is choosed based on the high contrast than 5×5, 7×7, 9×9, and 11×11. The filters in the Noise Reduction class are designed to remove extreme or outlier values from image areas that should have relatively uniform values.

7. PERFORMANCE EVALUATION

It is very difficult to measure the improvement of the enhancement objectively. If the enhanced image can make observer perceive the region of interest better, then we can say that the original image has been improved. In order to compare different enhancement algorithms, it is better to design some methods for the evaluation of enhancement objectively. The statistical measurements such as variance or entropy can always measure the local contrast enhancement; however that show no consistency for the MRI. Performance of the Median filter, Weighted Median filter, Adaptive filter and spatial filters are analysed and evaluated using the following equations.Table8 shows the performance of listed filters.

1) Contrast
2) Contrast Improvement Index(CII)

C processed and C original = Contrasts of MRI __________________ (1)

$C = (f-b) / (f + b)$______________(2)

f = mean gray -level value of the foreground, b= mean gray-level value of thebackground

Noise level= standard derivation (σ) of the background

$\sigma = \sqrt{(1/N) \sum (bi-b)^2}$______________(3)

bi = Gray level of a background region

N= total number of pixels in the surrounding background region (NB)

$PSNR = (p-b) / \sigma$ __(4)

$ASNR = (f-b)/ \sigma$__(5)

Where p is the maximum gray-level value and if is the average gray level of a foreground. The value of two indexes are larger, the enhancement method performance better. Our proposed method we choose weighted median filter is highly contras than other three filterst based on the below statistical analysis from PANR and ASNR values. Figure8 shows the value of Peak Signal-to-Noise Ratio (PSNR) for filters. Figure 9 shows the value of Average Signal-to-Noise Ratio (ASNR) for filters.

TABLE 8: PERFORMANCE ANALYSIS FILTERS

Sno	Filters	PSNR	ASNR
1	Median	0.91543	0.9267
2	Weighted Median	0.92667	0.9278
3	Adaptive	0.9126	0.9261
4	Spatial	0.89120	0.8991

FIGURE 8: PEAK SIGANAL-TO-NOISE RATIO (PSNR)

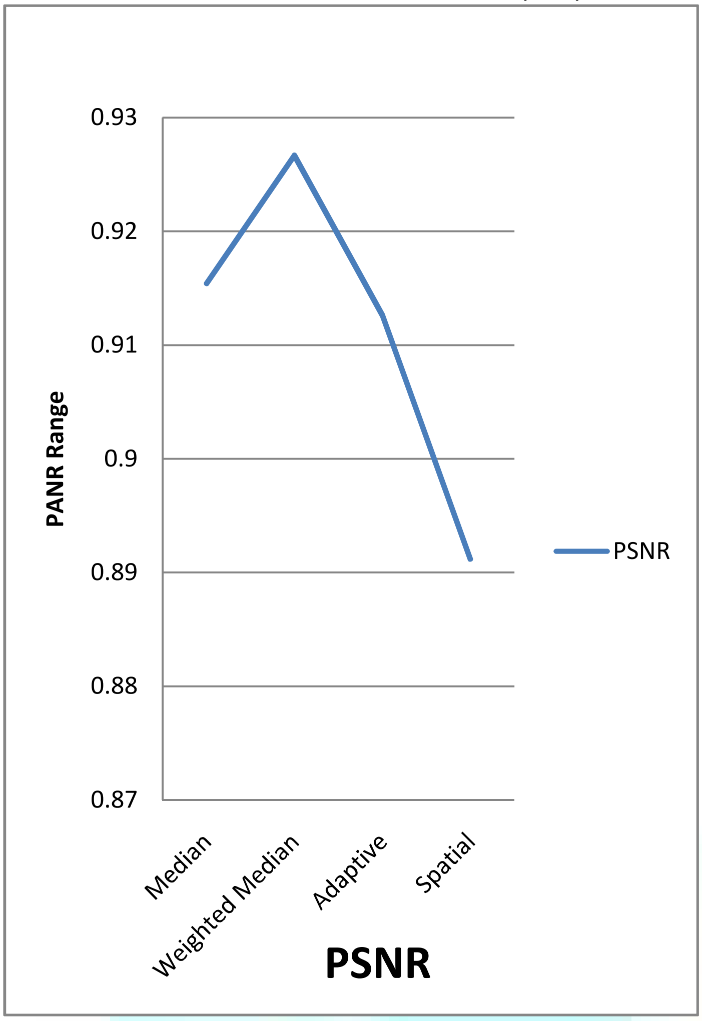
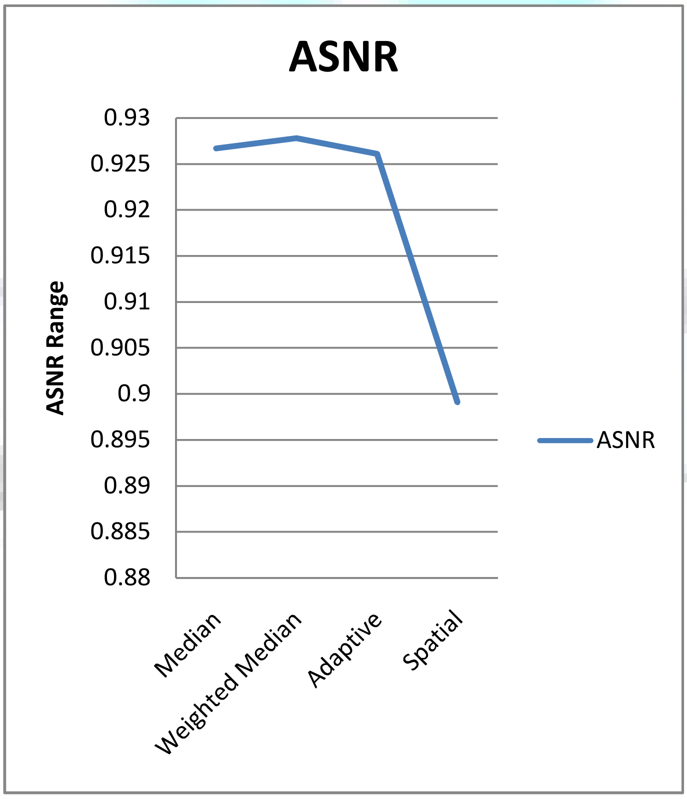


FIGURE 9: AVERAGE SIGANAL-TO-NOISE RATIO (ASNR)



CONCLUSION

This paper proposed a gradient based image enhancement method using first derivative and local statistics and showed the validity of detection of MRI. Initially the MRI brain image is acquired from MRI brain data set to MATLAB 7.1. After acquisition the MRI is given to the preprocessing stage, here the film artifacts (labels) are removed. Next, the high frequency components and noise are removed from MRI using the following filters. Such as Median filter, Weighted Median filter, Adaptive filter and spatial filter. The performance of above filters are measured and evaluated. Finally the best filter of weighted median filter is identified and used for MR brain image enhancement. It is used for removing noise from MRI brain images with high contrast.

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