STUDY AND ANALYSIS OF BRAIN TUMOR DETECTION THROUGH MAGNETIC RESONANCE IMAGING

MAJOR PROJECT

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CANDIDATE’S DECLARATION

I, Priyasha Parmar, an M.Tech (Signal Processing and Digital Design) student, hereby declare that the project Dissertation titled "Study and Analysis of Brain Tumour Detection Using MRI" that I submitted to the Department of Electronics and Communication Engineering, Delhi Technological University, Delhi in partial fulfilment of the requirement for the award of the degree of Master of Technology, is original and has not been copied from any source without proper citation. This work has never before been used to give a degree, diploma, associateship, fellowship, or other equivalent title or recognition.

Place: Delhi **NAME: Priyasha Parmar**

Date:

CERTIFICATE

I hereby certify that the Project Report titled "**Study and Analysis of Brain Tumour Detection using MRI**" which is submitted by **Priyasha Parmar**, **2K20/SPD/10** of Electronics and Communication Department, Delhi Technological University, Delhi in partial fulfillment of the requirement for the award of the degree of Master of Technology, is a record of the project work carried out by the students under my supervision. To the best of my knowledge this work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere.

Place: Delhi **Dr. Priyanka Jain**

Date: **SUPERVISOR**

To My Parents,

Mrs. Sunita Parmar & Mr. Pradeep Kumar Parmar

And

All My Teachers

# ACKNOWLEDGEMENT

A successful project can never be prepared by the efforts of the person to whom the project is assigned, but it also demands the help and guardianship of people who helped in completion of the project.

I would like to thank all those people who have helped me in this research and inspired me during my study.

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I take immense delight in extending my acknowledgement to my family and friends who have helped me throughout this research work.

NAME: Priyasha Parmar

ABSTRACT

Magnetic Resonance Imaging (MRI) is playing a very significant role in detection of various abnormalities in the human body. Biomedical image processing is helping us in the proper identification of various abnormalities such as a malignant tumours in various parts of the body. In this thesis titled **"Study and Analysis of Brain Tumour Detection through Magnetic Resonance Imaging (MRI) "** different types of filtering methods applied in the pre-processing stage have been compared. When MRI images have been corrupted by Gaussian noise then various filters are applied to obtain recovered MRI images. After performing the filtering operation segmentation has been applied to MRI images to obtain the tumour region. The processes have been implemented with the help of MatLab 2018.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Recently several advances have been made in the field of application of image processing in medical applications [1]. Brain tumours are one of the deadly diseases with a low survival rate [2]. According to the statistics provided on cancer.net, it is the 10th leading cause of death [2]. According to the World Health Organization (WHO) [3], tumours can be graded from grade 1 to grade 4 and this can be used to classify them into benign or malignant tumours or non cancerous and cancerous. Non cancerous tumours are from grade 1 and grade 2 and cancerous tumours are classified under grade 3 and grade 4 and hence called high-grade tumours [3]. Early detection of low-grade tumours is very crucial because if these tumours are left unchecked then they may turn into high-grade tumours.

Generally, oncologists use MRI to obtain brain scans and detect any abnormal growth. However, manually reading MRI Scans is highly prone to errors. Sometimes MRI scans may even be corrupted by noise which again hinders proper identification of brain tumours. Hence, various image pre-processing techniques such as image filtering, segmentation, morphological operations etc. can provide very detailed images of the various tissues inside our body. With these detailed images, doctors can make a timely and efficient proper diagnosis [4].

1.2 Biomedical image processing

Medical image processing is an emerging area with millions of dollars invested in this industry. It has applications in almost every medical field including radiology mammography cardiology oncology. Using advanced medical image processing techniques doctors can plan surgical interventions or diagnosis accordingly[3].

With help of these image processing techniques we can explore various data sets of the human body which are obtained using ultrasound techniques or computed tomography or in this case magnetic resonance imaging[3]. Using advanced medical image processing techniques doctors can plan surgical interventions or diagnosis accordingly.

Medical image processing carries out various types of operations which can be listed below[3] :

1. It can be used to reduce or remove different kinds of noise such as Rician noise
2. Using image segmentation methods we can determine various types of different tumors another abnormalities
3. Input data can be re-sampled as well as cropped and it can be used for faster computations
4. Using image data and data sets for different measurements and statistics
5. Performing filtering operations so that we can obtain enhanced images

Hence medical image processing is a growing field with multiple applications in various industries and in present times.

1.3 Magnetic Resonance Imaging in noisy environments.

Magnetic resonance imaging or MRI scanners which are available in hospitals is basically a very large magnet whose value could be measured in tesla. It is up to 1.5 or 3 T and it is extremely strong, around 60,000 times stronger compared to earth‘s magnetic field. Using this magnetic field various tissues such as human internal organs or tumors or any other defects growing inside of the human body could be monitored easily.

MRI uses magnetic or radio waves and then it measures the amount of water which is present inside the different tissues of the body hence we are able to form very detailed images using this information. Sometimes while taking MRI scans noise is introduced in the environment.

Sometimes in clinical diagnosis the magnetic resonance 3-D and 2-D images are severely affected by noise and by applying the correct filtering technique we can accurately determine any abnormalities.

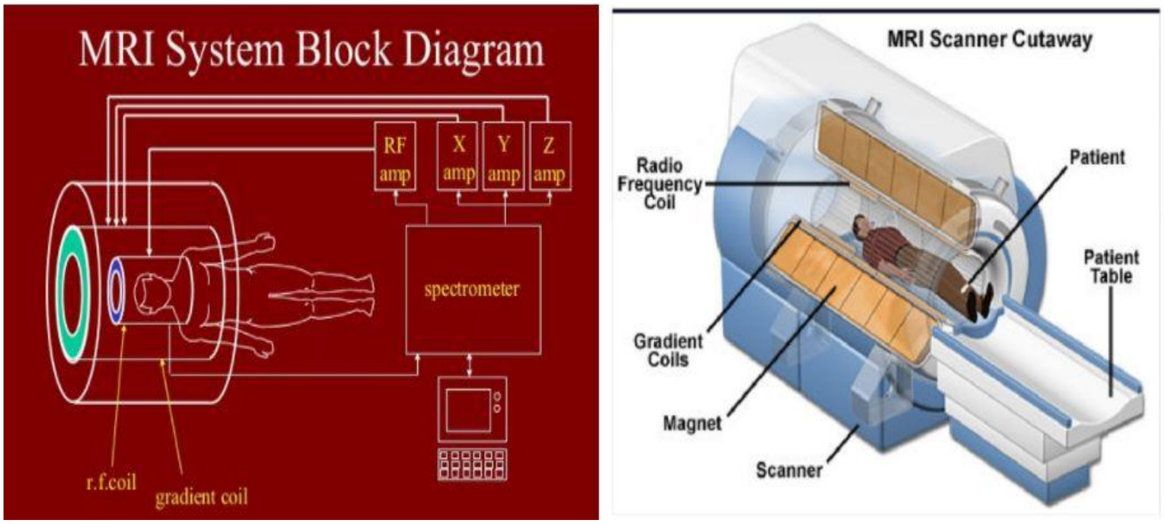


Fig 1 : Magnetic Resonance Imaging Block Diagram[3]

Several research has been done in de noising techniques. Basically the main challenges which is present while the de noising magnetic resonance images is to preserve the edges and all the small structures which are essential for making a right diagnosis[4].

Three main methods can be identified for performing MRI denoising filter[4].

1. Spatial domain : they perform the average of the signal while reducing noise
2. Transformed domain
3. By exploiting statistical properties of signal

These methods help in removing noise and retain essential features in MRI images important for making a diagnosis.

1.4 Motivation

Timely and efficient diagnosis of various cancerous tissues growing inside the body is crucial. However, it depends on doctors manually identifying the malignant region inside the brain. This process is highly inefficient. Sometimes it becomes very difficult to take MRI brain scans in a noisy environment. Image processing techniques based on anisotropic diffusion filtering can further help in faster and more efficient detection of various tumours drawing inside the brain. To enhance the quality of MR Images various denoising filters are available in the image processing. In this paper, a comparison of various nonlinear filters has been done on the basis of the calculation of performance parameters Peak Signal to Noise Ratio(PSNR) and Signal to Noise ratio (SNR).

1.5 Objective

In this paper different types of filtering methods applied in the pre-processing stage have been compared. When MRI images have been corrupted by Gaussian noise then various filters are applied to obtain recovered MRI images. After performing the filtering operation segmentation operations based on thresholding and machine learning has been applied to MRI images to obtain the tumour region. The processes have been implemented with the help of MatLab 2018.

1.6 Organisation of Major Project Report

This major project report is organized into following chapters. In Chapter 1, it begins with the introduction and need for filtering methods for MRI brain tumour detection in noisy environments. It is then followed by motivation and objective. Chapter 2 includes literature survey for brain tumor detection in noisy environment. Chapter 3 includes design and methodology . Chapter 4 includes the simulation work done on matlab 2018 for MRI brain tumor analysis.Chapter 5 includes conclusion and future scope

CHAPTER 2
LITERATURE REVIEW

Anisotropic diffusion filter technique was proposed by Witkins [1] where original images are convolved with Gaussian kernels to obtain the final image. However, accurate locations of different meaningful edges could not be obtained. Perona and Malik *et al.* [1] have used partial differential equations to describe anisotropic diffusion and filtering technique. Using anisotropic diffusion filtering techniques to obtain sharp region boundaries in the images [1]. Hence the issue of blurring was solved and sharp edges could be retained. However, the suggested anisotropic diffusion filters technique has not been applied to MRI images.

MRI evaluation used anisotropic diffusion filtering for preserving edges and MRI intensities were suggested by Palma Cappabianco ide Miranda *et al.* [4]. However, no analysis of the performance of the anisotropic diffusion technique has been done if MRI images are corrupted by Gaussian noise.

Bahadure *et al*.[5] worked on image analysis for MRI image brain tumour detection and extracting essential features using biologically inspired Berkely wavelet transform and Support Vector Machine[5]. Berkeley wavelet transformation for the brain tumour segmentation has been performed. Support vector machine classifiers are also being used to extract certain features from the tissues [5]. They have then utilized a certain threshold value for identifying and contouring images. However, the behaviour of MRI images under noisy conditions in pre-processing steps is not observed.

Rashid *et al*. [6] research work on anisotropic techniques and SVM classification have also proposed various morphological operations and anisotropic diffusion filters for segmentation and identification of infected brain tumour tissues. The author has tried to filter MRI images that were corrupted because of salt and pepper noise. However, MRI images corrupted by Gaussian noise is not considered.

TABLE 1 : LITERATURE SURVEY ON PREVIOUS WORK DONE

Sno.	Paper name	author	Techniques learned
1.	Enhanced Image Filtration Using Threshold based Anisotropic Filter for Brain Tumor Image Segmentation	A.Mohan Rethinam 1	Anisotropic filter bounding box approach
2.	Anisotropic Diffusion filtering Operations MRI evaluation used and isotropic diffusion filtering for preserving edges and MRI intensities	Palma Cappabianco ide and Miranda	It was found that a DF relatively blurs the edges when it is trying to remove induced noise level. Hence a robust framework that adjusts ADF parameters based on the statistics obtained from ages and from planer region
3.	MRI-based brain tumor detection and feature extraction using biologically inspired BWT and SVM	NB Bahadure AK Ray and HP Thethi	Here Berkeley wavelet transformation in segmentation of brain tumoris performed. Support vector machine classifiers are also being used so as to extract certain features from the tissues. They have then utilized a certain threshold value for identifying and contouring images.
4.	Denoising mri images	hanafy m Ali	First salt and pepper and Gaussian noises are being added to the MRI images then a median filter is applied to extract the desired image.Later on SNR and psnr was calculated. However the processing time and memory was increased when we compared it to adaptive linear and adaptive median filter by approximately 400%
6.	scale space and edge detection using anisotropic diffusion	Perona and Malik	one of the problems was That we could not obtain accurate locations of different meaningful edges at coarse scales. Using nonlinear anisotropic diffusion filtering techniques we can obtain sharp region boundaries

Hanafy m Ali *et al*. [7] noise removal can cause various challenges such as various important features of MRI could be blurred due to which visualization and detection of the tumour could become a problem [7]. Here the median filter algorithm is being used and it is modified. First salt and pepper and Gaussian noises are being added to the MRI images then a median filter is applied to extract the desired image[7]. Here denoising of MRI images is performed only using median and adaptive median filters. Other edge detection techniques like guided filters or non-local means have not been explored.

Mariam Saii, Zaid Kraitem in their paper Automatic Brain Tumor Detection in MRI Using Image Processing Techniques(2017) [6] offers an appropriate method for performing brain tumor segmentation on brain MRI images containing tumor region. At the first stage anisotropic diffusion filter to the image to remove unwanted noisy signal. In the next stage they perform support vector machine classifiers are applied for detecting the tumor area and also obtaining mask region by performing morphological operations of erosion and dilation. Dice coefficients of more than 0.9 are used for detecting and segmenting the tumor.

CHAPTER 3

DESIGN AND METHODOLOGY

3.1 DESIGN AND BASIC FLOWCHART

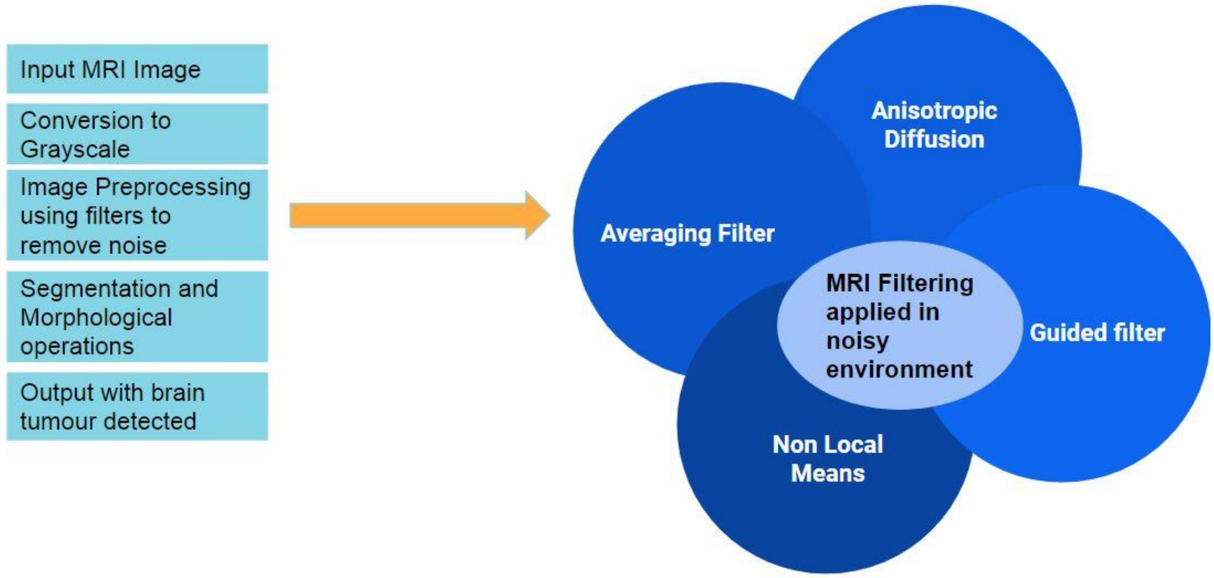


Fig 2 : Filters applied in pre processing stage to improve performance in noisy environment

First input, MRI image is converted to grayscale for ease of performing further operations Applying image processing operations like segmentation on corrupted images give us inaccurate results. Hence, pre-processing filtering techniques are applied. After removing noise, a segmentation operation is applied. Segmentation involves breaking up images into subgroups called segments. This makes performing further operations easier with reduced complexity. Then Morphological operations such as erosion , dilation. Dilation adds pixels to object boundaries while erosion removes pixels on object boundaries are applied. These operations process the digital images based on their shape[10]. The corresponding pixel in the input image is compared with its neighbours and the output image is obtained. Hence at the output brain tumour region is detected inside the MRI brain scan[10].

3.2 Preprocessing Methods

Pre processing of MRI images in image processing is one of the most important steps**.**This is because sometimes noise is introduced in MRI images and corrupts the image. This makes detection and diagnosis Of the brain tumour very difficult[11]. The noise which is introduced in the MRI images corrupts the edges and significant features of the image. As a result the identification of a malignant tumour becomes very difficult[11]. Hence we apply pre-processing techniques on the image processing specially in case of a noisy environment.

Pre-processing stage involves application of certain filters to remove the unnecessary noise present in the MRI images while preserving the certain significant features in the images[7].

To preserve certain significant features inside the MRI images for further detection of the plane team are we need to apply appropriate filters. An ideal filter for such such applications would be one which is able to preserve and highlight certain features. Hence edge detection filters are used in the pre-processing stage.

Certain edge detection filters like and isotropic diffusion filters, non-local means filter, guided filter are applied in the pre-processing stage and their performance under noisy condition is being determined[7].

3.3 Pre Processing of Magnetic resonance images with brain tumor using various filtering techniques

Digital filtering employs various mathematical equations performed on the image to obtain the output cleaned image. Sometimes MRI images are corrupted when noise is introduced in the system.The noise can be modelled as gaussian noise. Gaussian noise is considered because it is additive in nature and it is easier to model noise which might be introduced in MRI scans[10].

Filtering techniques

In computer vision and image processing we have various types of partial differential equation-based techniques for performing the filtering, smoothing and restoration of different images. If magnetic resonance images are cluttered with the presence of noisy components then it becomes very difficult to exactly detect the tumours and hence it hinders proper diagnosis. So we need to perform adequate filtering operations to overcome these problems[10].

One of the major tasks of filtering techniques or image restoration is removing noise which corrupts the image. Various types of filters such as a mean filter or median filter can be used for noise removal[10].

Linear filtering

There are various techniques in image processing which are based on partial differential equations. Partial differential equation methodology can be used for restoration or if you want we can also perform smoothing of the images.

Linear filtering is a traditional approach. It is a type of scarce space approach which was very commonly used for performing filtering or for smoothing an image or in a controlled manner[10].

What we do here is that we convolve our original image with the given Gaussian kernels and here we obtain the filtered output.

However one of the major drawbacks of linear filtering is that while performing filtering operations for the removal of noise edges are not preserved to that extent.

Nonlinear Diffusion filtering

This type of diffusion filtering helps to improve the quality of the image while removing the noise. Here we can observe that the edges are preserved and the details are observable hence it is easier to identify the brain tumour growing inside the tissue.

Here we apply the anisotropic diffusion filtering technique which has been proposed by Perona and Malik in their skills pace approach to isotropic diffusion filtering.

There are certain diffusion coefficients which are then locally adapted and hence they end up becoming negligible as we approach the boundaries of the object. In the final result we can observe that the noise will be removed. The object contours will be enhanced very strongly hence the entire operation is performed efficiently

Comparison of linear vs Nonlinear Diffusion Filtering

Filters used in image processing could be linear or nonlinear. Usually, Non-linear filtering techniques perform better in comparison to linear filtering methods [10]. This is because they are able to preserve significant brain tumour tissue important for tumour detection and identification [10]. The comparison of the behaviour of linear vs non-linear filters is given below in figure .

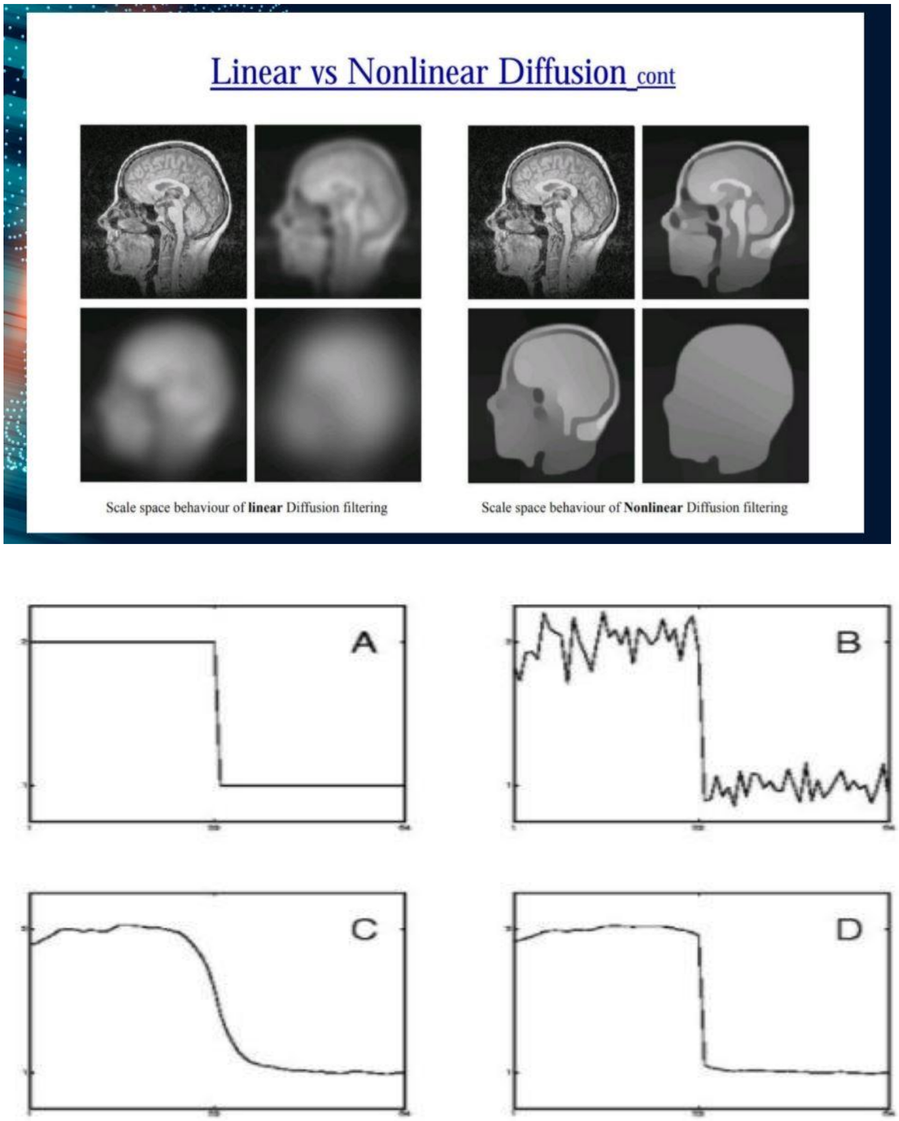


Fig 3 : Left to right: Linear Filtering performed on MRI image corrupted with noise, Non-Linear Filtering performed on MRI image corrupted with noise, Comparison Between linear and nonlinear filtering[10]

Hence nonlinear filtering smooths out edges much better in comparison to linear filtering.In Figure 2 filtering operation on MRI images is compared between linear and non-linear filter. Linear filtering(Left) while removing noise from the MRI image distorts the edges present in the image. As a result, the image becomes blurred. Non-Linear Filtering(Right) effectively removes the noise from images while preserving their edges

Anisotropic Diffusion Filtering Techniques :

This Edge preserving diffusion filtering technique in image processing was formulated by Perona and Malik. They are used in magnetic resonance images for mainly smoothing and restoration[1].

The basic advantage which and isotropic diffusion filtering offers in the image processing are as follows:

- Partial diffusion equation based techniques hence they are mathematically sound and stable algorithms can be formulated using them. Hence one of the excellent techniques found in image processing
- It is a kind of scale space representation which can be used to extract semantically important information from the images
- Edges and other features are well preserved

Diffusion Process

Diffusion is a physical process that balances concentration differences without causing mass to be created or destroyed. This physical observation can readily be expressed mathematically.

Fick's law expresses the equilibration property[10]:

$$j = - D \cdot \nabla u \qquad (1)$$

j=flux

Δ u = concentration gradient

D= diffusion tensor

According to this equation, a concentration gradient which is u induces a flux j to compensate for the gradient. The diffusion tensor D, a positive definite symmetric matrix, describes the relationship between u and j[10] . Isotropic refers to the situation in which j and u are parallel. The diffusion tensor can thus be substituted by a positive scalar-valued diffusivity g. In the usual anisotropic case, j and u are not parallel.

By applying Continuity equation or conservation of mass we obtain[10]

$$\partial_t(u) = -\,div(j)$$

$$\partial_t(u) = div(D \cdot \nabla u)$$

Solution to above differential equation is

$$\partial_t u = div(d \nabla u)$$

This is very similar to convolving an image with a Gaussian kernel .

Anisotropic diffusion filter equations

According to Perona and malik

$$\partial_t u = div\left(g\left(|\nabla u|\right)\nabla u\right)$$

When we compare this equation with the above we find that the scalar diffusion constant D is exchanged with the scalar valued function g of gradient ∇u of grey levels present in the image[6]. When this operation is performed the equation can be modified as shown above.

There is a reason why this is known as nonlinear diffusion process. ∇u which is a good measure of the edge strength of current location is actually dependent upon the differential structure of the images which makes this process as nonlinear diffusion process[1].

$I = div\,(c(x, y, t)\nabla I) = c(x, y, t)\Delta I + \nabla c \cdot \nabla I$

I = Image under consideration

c = diffusion coefficient

div = divergence operator

∇ and Δ = Gradient and Laplacian operator

These filtering operations are applied to obtain enhanced images whose edges are preserved.

Averaging:

Average filtering in image processing tries to reduce the amount of intensity variation which is present between the neighborhood pixels. It normally goes pixel by pixel through the image. Then we replace each value with the average value of the neighbouring pixels.

Averaging Filter 3x3

$$\frac{1}{9} * \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

Fig 4 : Averaging Filter

This filter is a type of low pass filter and removes the noises from the MRI images[7]. It is actually a type of linear class without filter. Its moons the MRI images.

Guided Filters :

With high computational complexity is a guided filter when used for filtering out noise in an MRI image processing it preserves the sharpness and the edges[15]. They have significant advantages over filters like bilateral filters. This is because the problem of gradient reversal which occurs in the bilateral filter is overcome in guided filters[15].

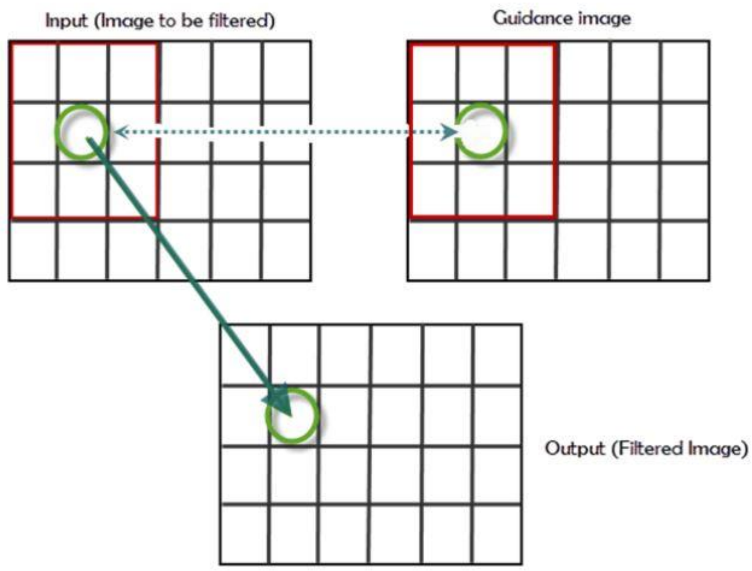


Fig 5 : Guided filter theory[15]

It consists of two images: an input image and a guidance image. The content of the second image, the guide image, is used in the input image. The input image of a version of the same image can be used as a guidance image[15].

In the above figure we can observe that there are two images: input image and guided image. Weights are generated using a guiding image for a particular pixel[36]. Then each of the pixels is multiplied by the input image with that weight.

$$q_i = \sum_j W_{ij}(I) p_j$$

Where I = guidance image

q = output

p = input

W = weight

i, j = pixel indexes

Advantages of guided filter are as follows[36]

- Better quality and efficiency
- Distinguishable edges are present in the filtered image because the problem gradient reversal is overcome
- Better speed of implementation when compared with bilateral filters

Disadvantages of guided filter is that it is dependent upon the guidance image. A sharp guidance image is crucial for efficient performance of a guided filter.

Non local means filter

First pixel weight for filtering noisy MRI images are identified [35].This is done by using all conceivable self-predictions and self-similarities provided by the image[35]. It is assumed that the image contains a large degree of self-similarity. Because the pixels are so closely connected, the noise is often spread independently and equally, therefore averaging these pixels is a good idea. The nonlocal-means filter reduces noise and sharpens edges without sacrificing too many fine details structure and specifics[35].

The pixel's colour is replaced by average of nearby pixels.The most comparable pixels to a given pixel, on the other hand, have no need to be close[35].

Advantages of non local means filter

It is used because it cleans the image containing noise without losing much of the significant details and edges[34].

Disadvantages of non local means filter :

The main disadvantage of nonlocal means filter is that then the noise increases and its performance deteriorates substantially[34]. That the noised image often suffers from the problem of blurring and there is subsequent loss of image details[34].

3.4 Performing Tumor Detection using Morphological Operations

In image processing we apply certain operations called morphological operations. These operations process the digital images based on the shape. The corresponding pixel in the input image is compared with its neighbours and this is how we obtained our output image. Here a small Matrix called as the structuring element is employed. This Structuring element Matrix can be represented by a rectangular matrix of odd dimension.In fact structuring element in morphological operations can be compared with the convolving mask operation in filters in image processing[37]. If use a binary structuring Matrix it basically contains zero and one[37].

Erosion:

It is opposite or compliment of a dilation is. It causes an object to reduce its size. It actually reduces the structure which are less when compared with the structuring matrix[37].

$$A \ominus B = \{z \mid (B)_z \subseteq A\}$$

Where is our image and B is a structuring Element or Matrixx

Dilation

With help of dilation we can make an object grow in size. And the extent of growth can be controlled with the help of the structuring matrix[38].

$$A \oplus B = \{z \mid (\widehat{B})_z \cap A \neq \emptyset\}$$

Where A is our image and B is the structuring element or Matrix[38].

Comparison between Erosion and Dilation

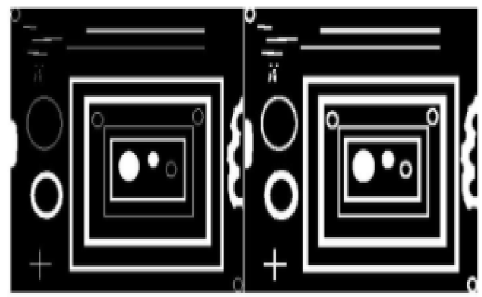
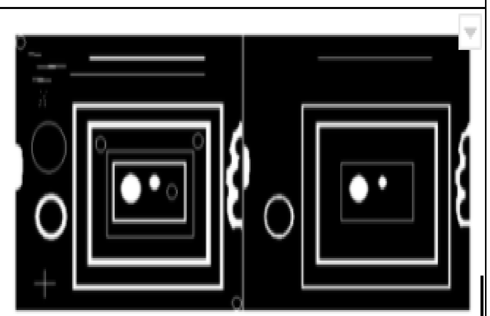
Operation	Rule	Example(original and Processed)
Dilation	The value of the output pixel is the *maximum* value of all pixels in the neighborhood. In a binary image, a pixel is set to 1 if any of the neighboring pixels have the value 1. Morphological dilation makes objects more visible and fills in small holes in objects.	
Erosion	The value of the output pixel is the *minimum* value of all pixels in the neighborhood. In a binary image, a pixel is set to 0 if any of the neighboring pixels have the value 0. Morphological erosion removes islands and small objects so that only substantive objects remain	

Fig 6 : Comparision between operations of erosion and dilation in image segmentation[37]

Dilation	Erosion
It increases the size of the objects.	It decreases the size of the objects.
It fills the holes and broken areas.	It removes the small anomalies.
It connects the areas that are separated by space smaller than structuring element.	It reduces the brightness of the bright objects.
It increases the brightness of the objects.	It removes the objects smaller than the structuring element.
Distributive, duality, translation and decomposition properties are followed.	It also follows the different properties like duality etc.
It is XOR of A and B.	It is dual of dilation.
It is used prior in Closing operation.	It is used later in Closing operation.
It is used later in Opening operation.	It is used prior in Opening operation.

Fig 7 : Comparsion between erosion and dilation [37]

3.5 Segementation Techniques for brain tumor detection

Image segmentation involves the process of segmenting or dividing the images into different parts for ease of analysis. We can segment the images on basis of certain similar attributes which the image might contain[38]. Such segmentation techniques find applications in facial recognition computer vision medical image processing. In MRI image processing segmentation is very important in identifying cancer cells or malignant tumour growth[38].

Classification of image segmentation

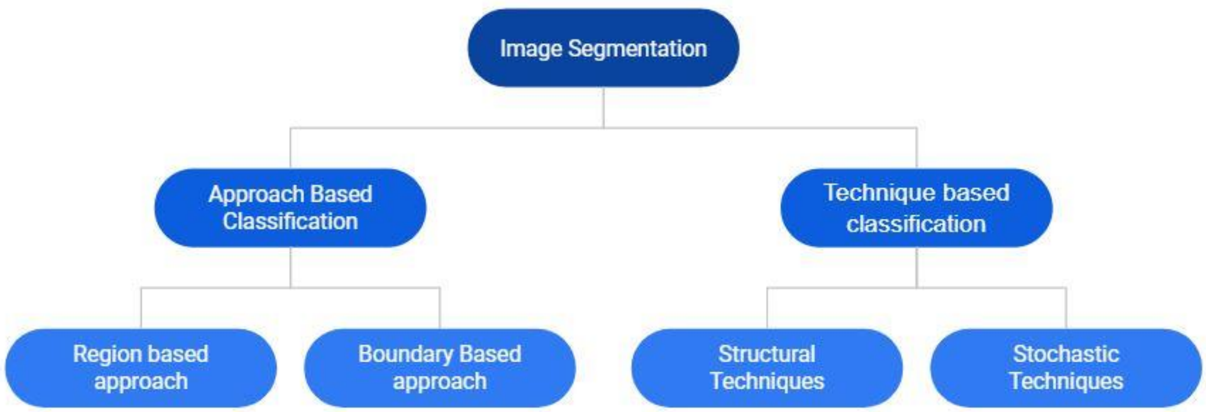


Fig 8 : Classification of image segmentation techniques[38]

Approach Based classification:

This type of segmentation approach is based on similarity of the pixels. It comprises of two approaches: region-based and boundary-based. Region based approach focus on grouping similar pixels together according to selected threshold[39].

Boundary based approach is just reverse to region based approach. Here we find features which are dissimilar to each other and separate them from the rest of the images. Some examples include line detection, point detection and edge detection where edge of dissimilar pixels are detected and separated from rest of the image.

Technique based approach:

It is employed based on the type of data that needs to be extracted from images. Structural Pixels, histograms, pixel density, and other pertinent information are extracted using techniques[39]. Instead of the structure of the needed section of the image, stochastic approaches use information about discrete pixel values. Examples of stochastic techniques include k means clustering and other machine learning algorithms.

Different Methods of image segmentation techniques

Different methods of segmentation techniques are described below

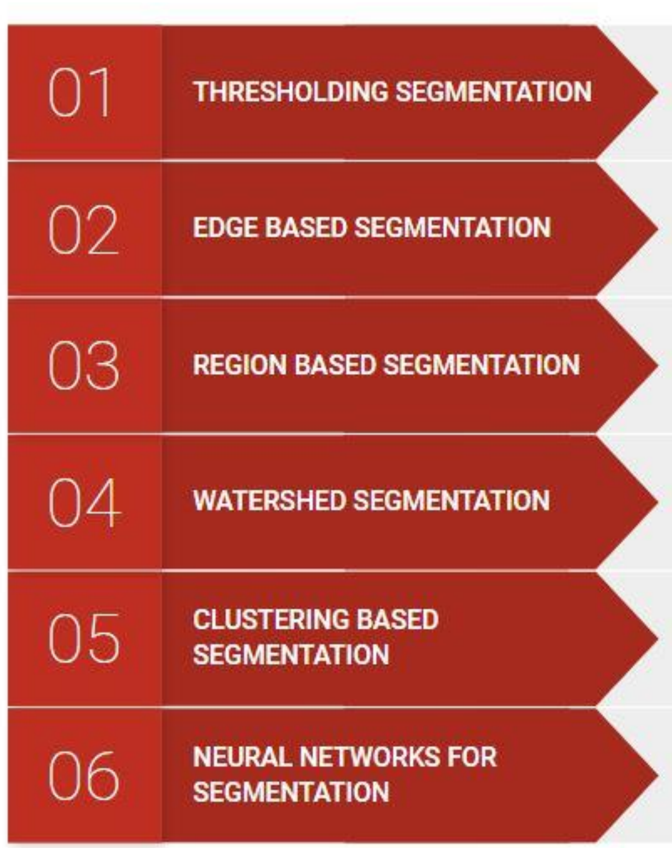


Fig 9 : Segmentation Techniques[39]

Thresholding segmentation

It is one of the most simplest technique where pixels are grouped according to their intensity values. This technique is suitable for mri brain tumor detection[29].This is because tumor area is hard compared to other tissues inside the brain . Hence in MRI scans tumor has higher intensity. By applying thresholding technique we can separate brain tumor according to their intensity values from rest of the tissues inside the brain[28]. Thresholding gray scale images are transformed into binary images so taht it is easier to separate them to required and not required parts. There are different types of thresholding methods present[28].

1. **Simple Thresholding Method:**

   Here intensity of the pixel is compared with a particular threshold value. If it's intensity is less compared to threshold value then the pixel will be replaced with black otherwise it is replaced with white[28].

2. **Adaptive thresholding method**:

   In simple thresholding we had one constant value for for classifying the pixels into two separate parts. However having a constant threshold does not always works with all the images. For this adaptive fresh holding is used where a variable threshold is chosen for different sections of the image. This type of dress holding works well in different lighting conditions[28].

Edge based Segmentation

Edges present inside the image and one of the most crucial features of MRI image because they contain a lot of information and they need to be preserved[26] . Edge based segmentation techniques focus on preserving these structures. There are different types of edge based segmentation techniques[26].

Search based method for edge detection:

To locate local directional maxima of the gradient magnitude, search-based edge detection algorithms look for local directed maxima of the gradient magnitude using a computed estimate of the edge's local orientation[25].

Zero crossing method based Edge detection:

Derivative functions are extracted from images. Then algorithm search for zero crossings to perform edge detection[25].

Region identification based Segmentation

In region-based segmentation features in the image which are similar are grouped together. Here a seed point is identified. Seed points can be a small section or a large portion of the input image. A region-based segmentation method would either increase or reduce the seed points' pixels, allowing them to be blended with other seed points once located[27].

Watershed based image segmentation

This type of segmentation is applied on a greyscale image based on the idea of watershed or drainage or geological divide. The image is considered analogous to a topographic map in watershed method[25].

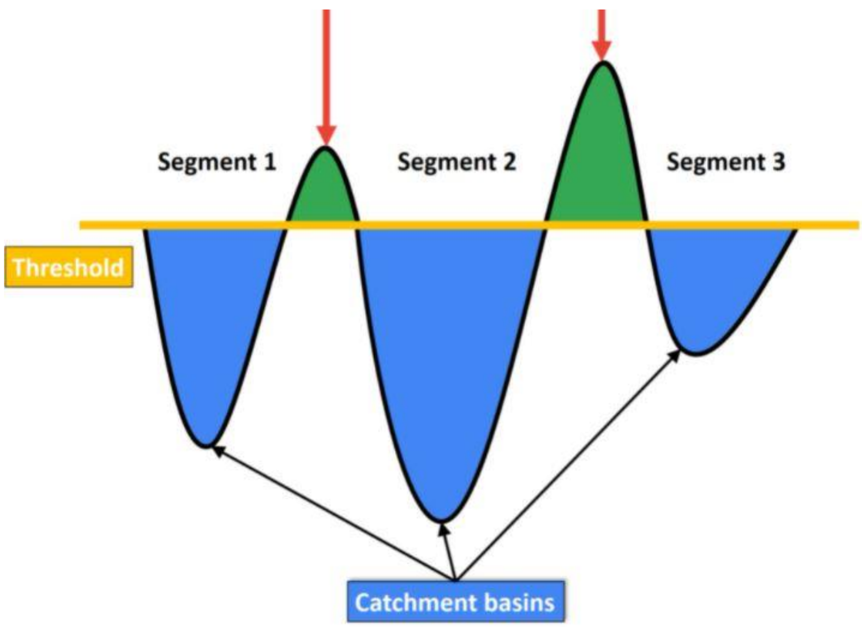


Fig 10 : Watershed segmentation [25]

Pixel's brightness is considered as its height and then it looks for the lines that run along the tops of the ridges[25].

Neural segmentation

Artificial Intelligence and convolution neural networks can be used to identify different components of images and can be used in image segmentation[21].

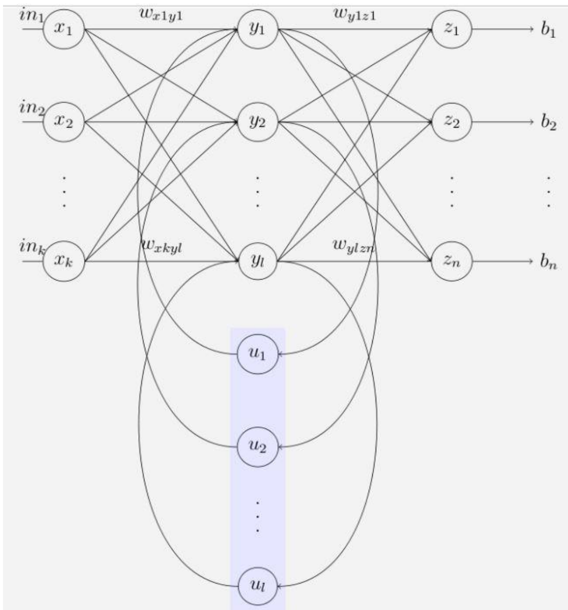


Fig 11 : Neural segmentation[21]

Neural Network methodology is used for performing image segmentation on MRI images[21].

Clustering based segmentation:

Clustering based segmentation divides images into 2 separate or disjoint groups. There are 2 types of clustering based segmentation which includes a) hard clustering b) soft clustering.

In hard clustering, the data point belongs to the cluster group entirely and it does not belong to the cluster group at all.

In soft clustering data point is not put in a particular group. Instead of putting the data point in a particular cluster the probability or the likelihood of the data pointed to belong to a particular cluster is determined.

The comparision between hard and soft clustering is further described in the figure given below:

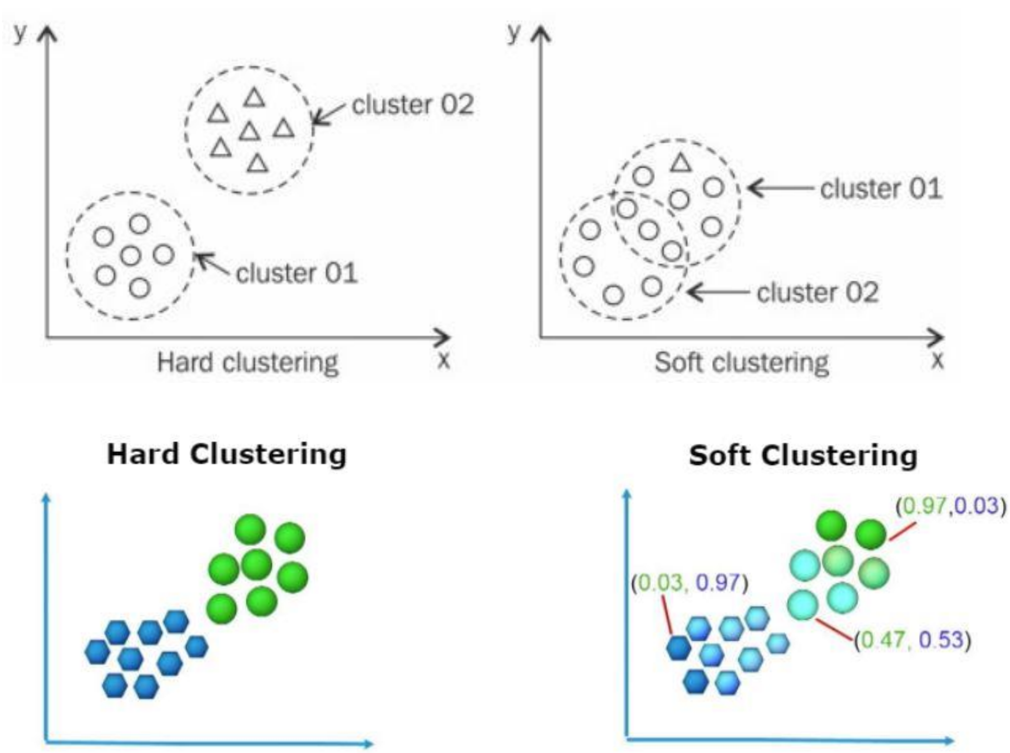


Fig 12 : Hard clustering vs soft clustering[22]

For brain tumour detection clustering-based segmentation approaches can be employed which are described below in the subsequent sections.

3.6 Clustering based segmentation approaches for brain tumor detection

Support vector machine(SVM)

This algorithm is developed by Vladimir N Vapnik and its later version developed by Cortes and Vapnik[23].

In support vector machine algorithms SVM Kernel function is used. This then transform a non-linear dividing objective into a linear transformation [23].

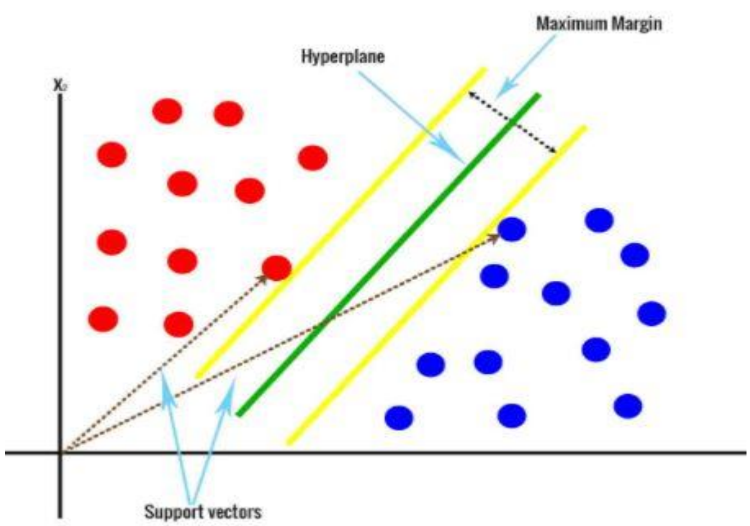


Fig 13 : Support vector machine [21]

The fundamental aim of the SVM method is conversion of a non-linear dividing objective into some type of linear transformation with help of a function called SVM's kernel function. The Gaussian kernel function was employed to convert the data in this investigation. The nonlinear samples can be translated into some type of high-dimensional space using a kernel function, allowing for the dissociation of nonlinear samples or data, making classification easier[39].

Fuzzy C means

Fuzzy c means is a type of soft clustering algorithm. Fuzzy C-Means clustering is a soft clustering method[22] . Here each data point is allocated a probability or likelihood score. With help of this likelihood score it determines whether it belongs to that cluster or not. The Fuzzy c-means clustering technique takes a step-by-step approach as shown in the flowchart below:

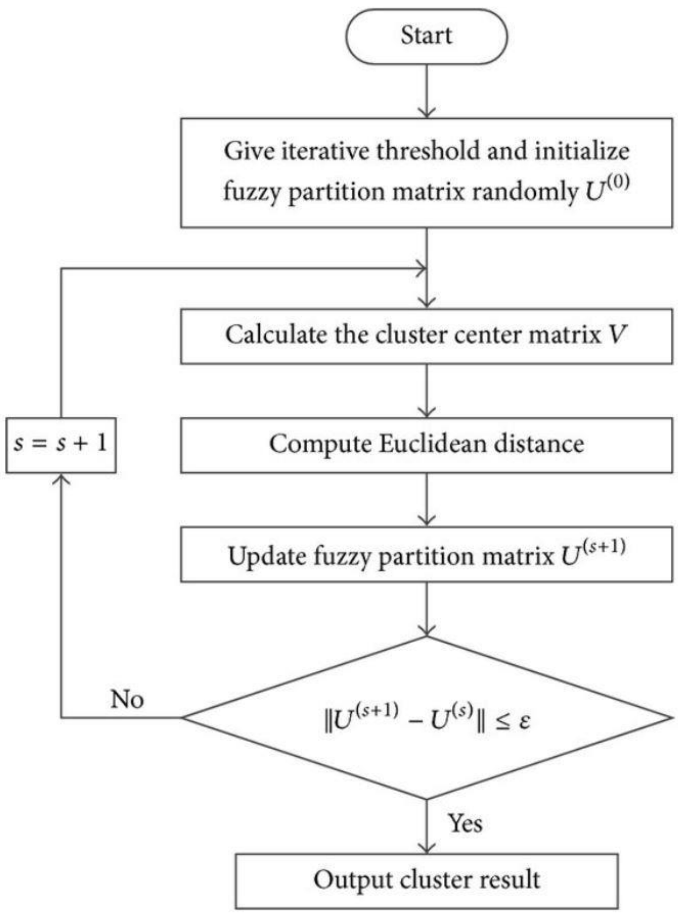


Fig 14 : Algorithm for fuzzy c means [22]

First fuzzy partition matrix is initialized. Then cluster center matrix V is calculated.After this the euclidean distance is measured and the fuzzy partition matrix U is updated[39]. Then MRI images sre visualised into two clusters[38]. One of the clusters contain the brain tumour region and the other conatins the remaining healthy portion of brain[39].

CHAPTER 4
EXPERIMENTAL RESULTS

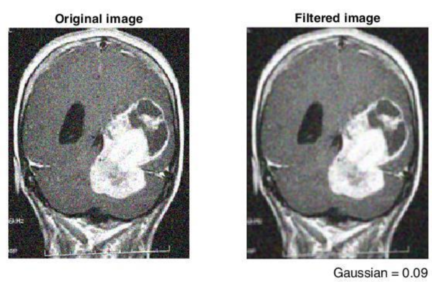
4.1 SIMULATION AND EXPERIMENTAL RESULTS

The coding is performed using Matlab r2018b. Different datasets and MRI images were taken for implementation of anisotropic diffusion techniques. Following are the implementation on a dataset with and without brain tumor.

4.1.1 COMPARATIVE ANALYSIS OF FILTERS IN PREPROCESSING STAGE

Comparative Analysis of filtering techniques applied on noisy mri images is performed and their signal to noise ratio (SNR)and peak signal to noise ratio(PSNR) is calculated.

TABLE 2 : Comparative Analysis of filtering techniques applied on noisy mri images

Sno.	Filter Methodology	Result
1.	Averaging	

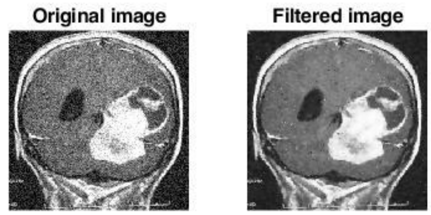
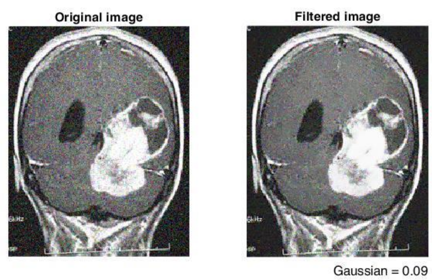
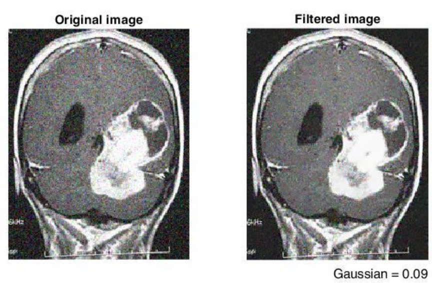
2.	Anisotropic	
3.	Guided	
4.	Non Local Means	

TABLE 3 : Performance Analysis using Signal to noise Ratio and Peak Signal to noise Ratio

Sno.	Filtering Techniques	Obtained Signal to Noise Ratio	Obtained Peak Signal to Noise Ratio
1.	Anisotropic Diffusion filter	16.4767	22.1250
2.	Averaging Filter	11.0165	17.7974
3.	Guided Filter	11.0111	17.7920
4.	Non Local Means Filter	11.0089	17.7899

Table 2 and Table 3 shows the SNR and PSNR of different filters applied at the pre-processing stage. SNR and PSNR are calculated using the formulas described below.

Let AxB be the image. If original AxB image is f(a,b) and filtered image be g(a,b)

SNR is calculated using below formula[7]:

$$SNR = \sum_{i=0}^{A-1}\sum_{j=0}^{B-1} g(a,b)^2 / \sum_{i=0}^{A-1}\sum_{j=0}^{B-1}[g(a,b)-f(a,b)]^2 \quad (3)$$

To calculate the PSNR, Mean squared error is measured using the formula given below[7]:

$$MSE=\sum_{A,B}[f(a,b)-g(a,b)]^2 / A*B \quad (4)$$

Here a, b are number of rows and columns of input image.

Then PSNR is calculated using the below formula[7]:

$$PSNR = 10\log_{10}(R^2/MSE) \quad (5)$$

Here R represents the maximum fluctuation in input image datatype. For eg. for an 8-bit unsigned integer datatype R is 255. On comparing values obtained in Table 3 it can be observed that the anisotropic filter performs better in comparison to other filters.

Then anisotropic diffusion filtering is applied to perform further operations to detect brain tumours.

Tumour detection was performed further using anisotropic diffusion filtering.

4.2 Tumour Detection using various segmentation Techniques

No tumor detected: Filtering is performed

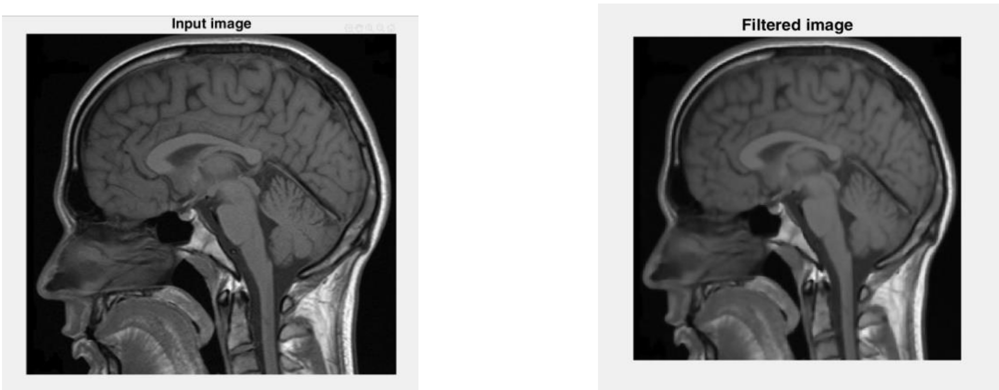


Fig 15: Input image of brain MRI Scan

No tumour is detected in this MRI Image. Hence output filtered image is obtained

4.2.1 Tumor detection using Thresholding

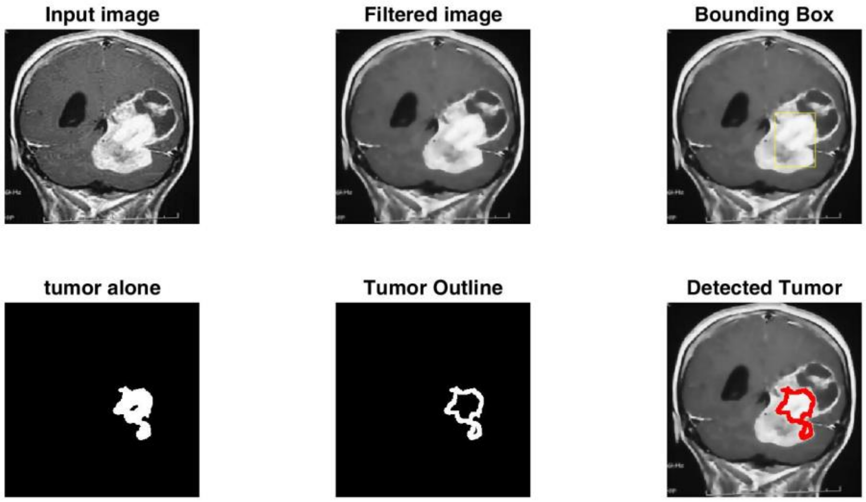


Fig 16 : Tumor detected (dataset 1)

Here tumour detection is performed using thresholding and bounding box approach.In bounding box approach the range of detection of tumour is reduced. Hence computing resources are preserved. The box here contains the information about the spatial location of malignant tumour growing inside the brain.

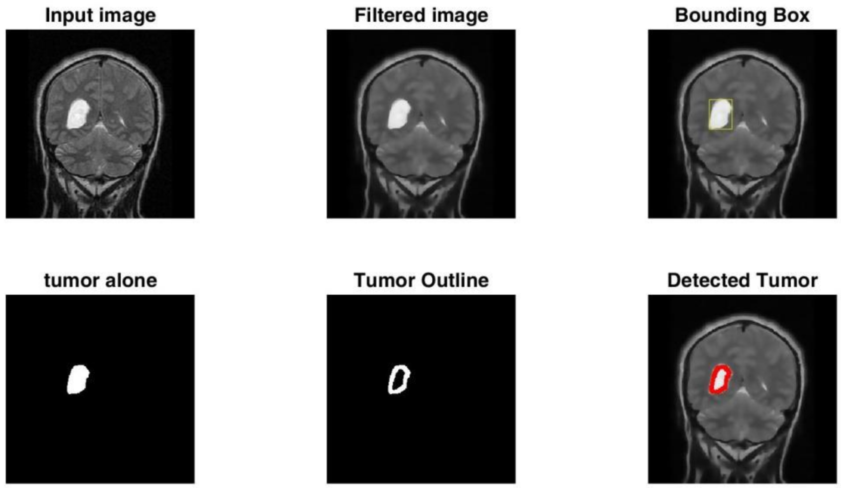


Fig 17 : Tumor detected (dataset2)

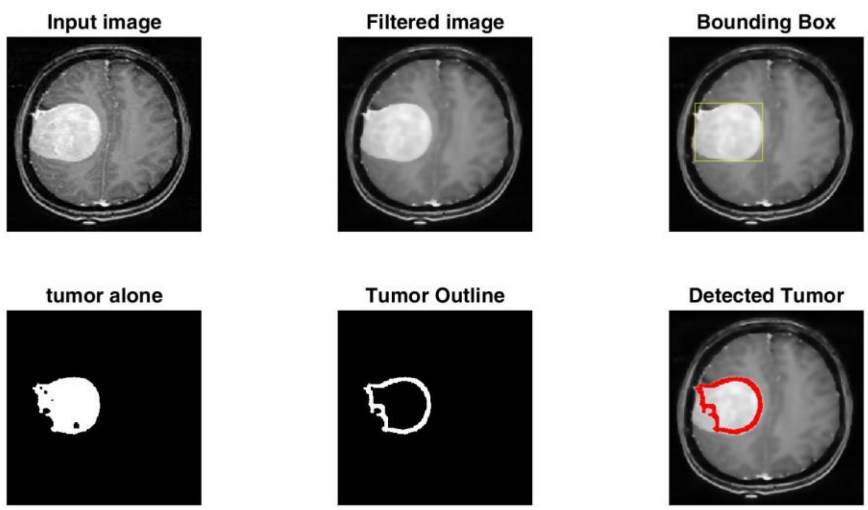


Fig 18 : Tumor detected (dataset 3)

In Fig 15 it can be observed that even though tumor is detected some portion of the tumour remains outside the red boundary line. This is because of the limitation of thresholding technique. To overcome this limitation machine learning techniques like fuzzy c means is applied.

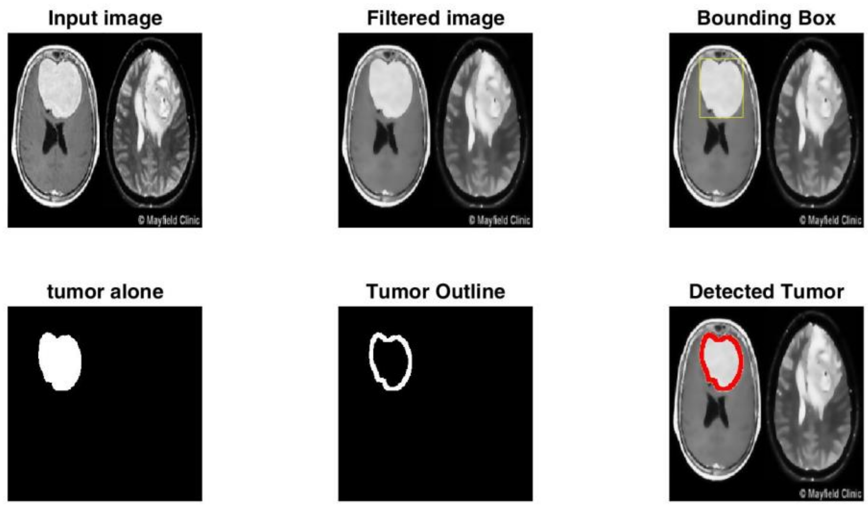


Fig 19: Thresholding Technique on 1*2 MRI Grid

Here thresholding and bounding box approach are not able to detect tumour in both images simulatneously. Hence machine learning techniques such as fuzzy c means are employed.

4.2.2 Tumor detection using Mchine Learning Techniques

Tumour detection performed using fuzzy c means is shown below:

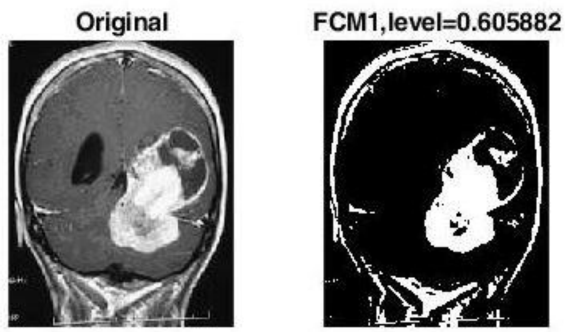


Fig 20: Tumour detection using Fuzzy C means (dataset 1)

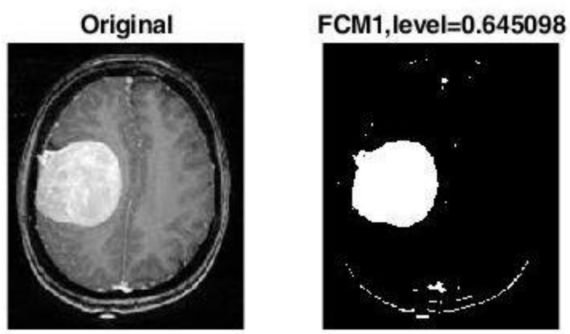


Fig 21 : Tumour detection using Fuzzy C means (dataset 2)

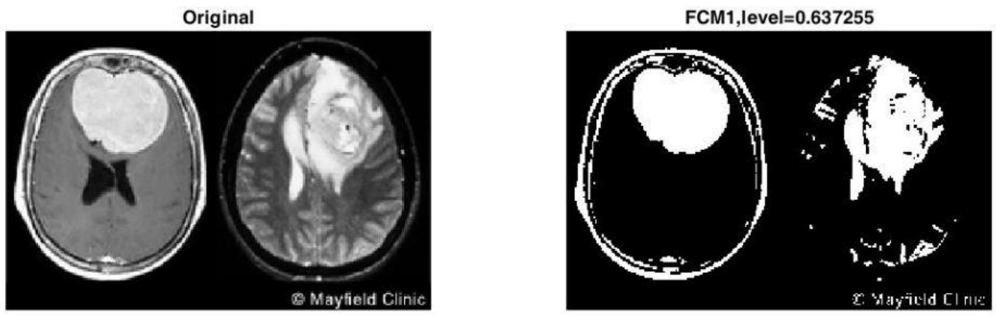


Fig 22 : Fuzzy C means on 1*2 MRI Grid

It can be observed from Fig 20 , 21 , 22 that Fuzzy C Means which is a soft clustering method help in accurate determination of malignant tumour region in brain.

Tumor detection using Support Vector Machine

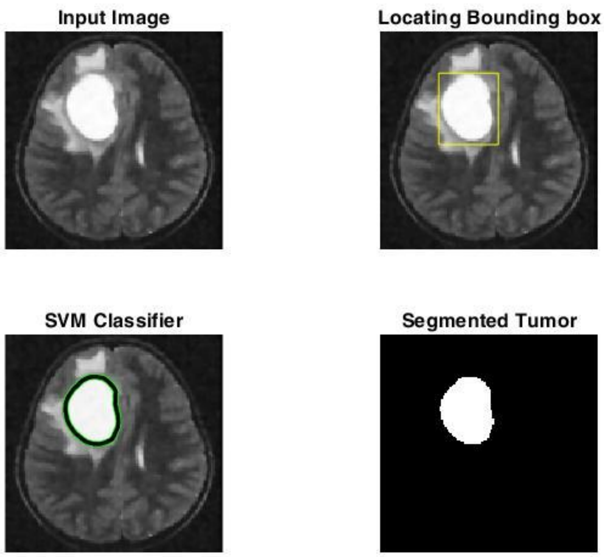


Fig 23 : Tumour detection Perrformed using SVM (dataset1)

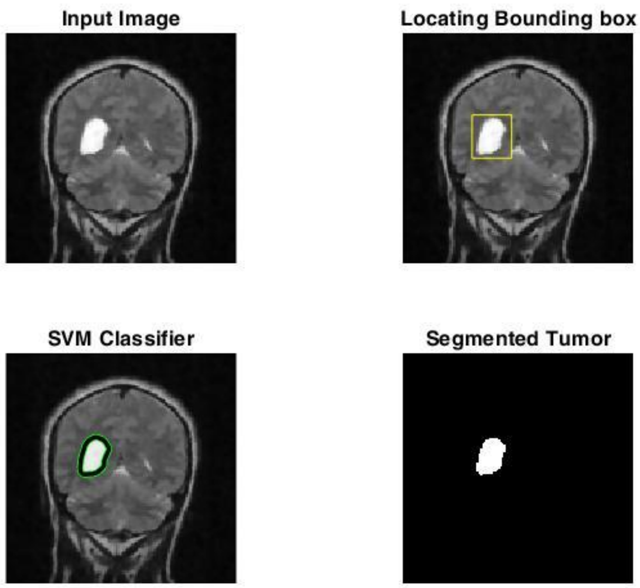


Fig 24 : Tumour detection Performed using SVM (dataset 2)

CHAPTER 5

CONCLUSION

As a result, nonlinear filtering methods such as isotropic diffusion filtering offer an advantage over linear filtering in terms of providing more visible edges. These edges are critical for detecting tumours and other disorders, as well as providing accurate diagnosis.

Following the application of appropriate pre-processing filters, segmentation is carried out using the thresholding method and machine learning techniques such as Fuzzy C means and Support Vector Machine. When compared to thresholding, it can be seen that fuzzy c means is a better technique. This is because it can quickly identify the full tumour location and work with MRI grid pictures. When compared to thresholding, SVM is faster.

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Analysis of various Pre-processing filtering methods for MRI brain tumour detection in a noisy environment

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Abstract. Magnetic Resonance Imaging (MRI) is playing a very important role in the detection of various abnormalities in the human body. Biomedical image processing is helping us in the proper identification of various abnormalities such as a malignant tumours in various parts of the body. In this paper different types of filtering methods applied in the pre-processing stage have been compared. When MRI images have been corrupted by Gaussian noise then various filters are applied to obtain recovered MRI images. After performing the filtering operation segmentation has been applied to MRI images to obtain the tumour region. The processes have been implemented with the help of MatLab 2018.

1. Introduction

Recently several advances have been made in the field of application of image processing in medical applications [1]. Brain tumours are one of the deadly diseases with a low survival rate [2]. According to the statistics provided on cancer.net, it is the 10^{th} leading cause of death in both men and women [2]. According to the World Health Organization (WHO) [3], tumours can be graded from grade 1 to grade 4 and this can be used to classify them into benign or malignant tumours. Benign tumours are from grade 1 and grade 2 and malignant tumours are classified under grade 3 and grade 4 and hence called high-grade tumours [3]. Early detection of low-grade tumours is very crucial because if these tumours are left unchecked then they may turn into high-grade tumours.

Generally, oncologists use MRI to obtain brain scans and detect any abnormal growth in it. However, manually reading MRI Scans is highly prone to errors. Sometimes MRI scans may even be corrupted by noise which again hinders proper identification of brain tumours. Hence, various image pre-processing techniques such as image filtering, segmentation, morphological operations etc. can provide very detailed images of the various tissues inside our body. With these detailed images, doctors can make a timely and efficient proper diagnosis [4].

There are different steps involved in brain tumour detection using image processing techniques. Major steps involved in medical image processing are listed in figure 1.

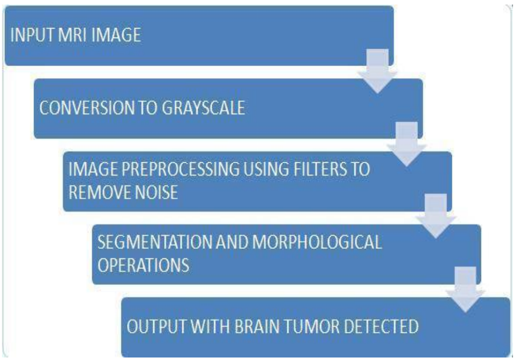


Figure 1. Block Diagram for brain tumour detection

First input, MRI image is converted to grayscale for ease of performing further operations Applying image processing operations like segmentation on corrupted images give us inaccurate results. Hence, pre-processing filtering techniques are applied. After removing noise, a segmentation operation is applied. Segmentation involves breaking up images into subgroups called segments. This makes performing further operations easier with reduced complexity. Then Morphological operations such as erosion and dilation. Dilation adds pixels to object boundaries while erosion removes pixels on object boundaries are applied. These operations process the digital images based on their shape. The corresponding pixel in the input image is compared with its neighbours and the output image is obtained. Hence at the output brain tumour region is detected inside the MRI brain scan.

2. Motivation

Timely and efficient diagnosis of various cancerous tissues growing inside the body is crucial. However, it depends on doctors manually identifying the malignant region inside the brain. This process is highly inefficient. Sometimes it becomes very difficult to take MRI brain scans in a noisy environment. Image processing techniques based on anisotropic diffusion filtering can further help in faster and more efficient detection of various tumours drawing inside the brain. To enhance the quality of MR Images various denoising filters are available in the image processing. In this paper, a comparison of various nonlinear filters has been done on the bases of the calculation of Peak Signal to Noise Ratio(PSNR) and Signal to Noise ratio (SNR).

3. Literature Review

Anisotropic diffusion filter technique was proposed by Witkins [1] where original images are convolved with Gaussian kernels to obtain the final image. However, accurate locations of different meaningful edges could not be obtained. Perona and Malik *et al.* [1] have used partial differential equations to describe anisotropic diffusion and filtering technique. Using anisotropic diffusion filtering techniques to obtain sharp region boundaries in the images [1]. Hence the issue of blurring was solved and sharp edges could be retained. However, the suggested anisotropic diffusion filters technique has not been applied to MRI images.

MRI evaluation used anisotropic diffusion filtering for preserving edges and MRI intensities were suggested by Palma Cappabianco ide Miranda *et al.* [4]. However, no analysis of the performance of the anisotropic diffusion technique has been done if MRI images are corrupted by Gaussian noise.

Bahadure *et al.*[5] worked on image analysis for MRI-based brain tumour detection and feature extraction using biologically inspired Berkely wavelet transform and Support Vector Machine[5]. Berkeley wavelet transformation for the brain tumour segmentation has been performed. Support vector machine classifiers are also being used to extract certain features from the tissues [5]. They have then utilized a certain threshold value for identifying and contouring images. However, the behaviour of MRI images under noisy conditions in pre-processing steps is not observed.
We have studied the various filtering techniques in digital image processing which is being tabularized in Table 1.

Table 1. Previous Works

Sno.	Title	Author	Findings
1.	Using Image Processing Techniques, Automatic Brain Tumor Detection in MRI[8]	Mariam Saii, Zaid Kraitem	The pre-processing level, anisotropic diffusion filter is applied to the MRI image. Pre-processing stage is not analysed under noisy conditions.
2.	Denoising MRI images [7]	Hanafy m Ali	First salt and pepper and Gaussian noises are being added to the MRI images then a median filter is applied to extract the desired image. Other edge detection techniques like guided filters or non-local means have not been explored.
3.	MRI-based brain tumour detection and feature extraction using biologically inspired BWT and SVM [5]	NB Bahadure AK Ray and HP Thethi	performed Berkeley wavelet transformation for the brain tumour segmentation. Support vector machine classifiers are also being used so as to extract certain features from the tissues. However, the scenario where MRI images are corrupted by Gaussian noise is not considered

Rashid *et al.* [6] research work on anisotropic techniques and SVM classification have also proposed various morphological operations and anisotropic diffusion filters for segmentation and identification of infected brain tumour tissues. The author has tried to filter MRI images that were corrupted because of salt and pepper noise. However, MRI images corrupted by Gaussian noise is not considered.

Hanafy m Ali *et al.* [7] noise removal can cause various challenges such as various important features of MRI could be blurred due to which visualization and detection of the tumour could become

a problem [7]. Here the median filter algorithm is being used and it is modified. First salt and pepper and Gaussian noises are being added to the MRI images then a median filter is applied to extract the desired image[7]. Here denoising of MRI images is performed only using median and adaptive median filters. Other edge detection techniques like guided filters or non-local means have not been explored.
In this paper, anisotropic filtering is applied to an MRI image under noisy conditions and a performance comparison has been done with the other existing nonlinear filters.

4. **Methodology**

Filters used in image processing could be linear or nonlinear. Usually, Non-linear filtering techniques perform better in comparison to linear filtering methods [10]. This is because they are able to preserve significant brain tumour tissue important for tumour detection and identification [10]. The comparison of the behaviour of linear vs non-linear filters is given below in figure 2.

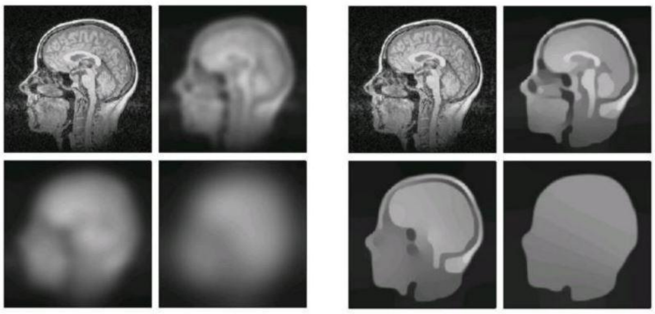


Figure 2. Left to right: Linear Filtering performed on MRI image corrupted with noise, Non-Linear Filtering performed on MRI image corrupted with noise, Comparison Between linear and nonlinear filtering[10]

In Figure 2 filtering operation on MRI images is compared between linear and non-linear filter. Linear filtering(Left) while removing noise from the MRI image distorts the edges present in the image. As a result, the image becomes blurred. Non-Linear Filtering(Right) effectively removes the noise from images while preserving their edges.

5. **Non-Linear Filtering Techniques**

In this section various nonlinear filters such as anisotropic diffusion, guided etc. have been explained in brief.

5.1 Anisotropic Diffusion Filtering Techniques:

This Edge preserving diffusion filtering technique in image processing was formulated by Perona and Malik [1]. They are applied in images for mainly smoothing and restoration. Anisotropic diffusion equation is [1],

$$I = \text{div}\ (c(x, y, t)\nabla I) = c(x, y,t)\Delta I + \nabla c \cdot \nabla I \qquad (1)$$

I = Image under consideration
c = diffusion coefficient
div = divergence operator
∇ and Δ = Gradient and Laplacian operator

These filtering operations are applied to obtain enhanced images whose edges are preserved.

5.2 Average filtering

Average filter image processing technique tries to reduce the amount of intensity variation which is present between the neighbourhood pixels. It usually moves through the image pixel by pixel. Further, replace each value with the average value of the neighbouring pixels [7].

5.3 Guided Filter

In a guided filter, there are two images: an input image and a guided image. Weights are generated using a guiding image for a particular pixel. Then each of the pixels is multiplied by the input image with that weight [15]. Although the guided filter preserves the sharpness and the edges of the MR Image it has high computational complexity. A variant of the input image could be used as a guidance image.

$$q_i = \sum W_{i,j}(I)p_j \qquad (2)$$

Where I = guidance image
q = output
p = input
W = weight
i, j = pixel indexes

Significant advantages in guided image filtering over other filters like better quality and efficiency in noise reduction in detail smoothing, no gradient reversal problem [15]. The only disadvantage is that guided filtering without a sharp guidance image might not work.

5.4 Non-local means filter

Local mean and non – local mean filters algorithm exists in the literature. In the local means algorithm mean value of a group of pixels surrounding a target pixel is taken to smooth the image [12]. However, in non local means filter takes mean of all the pixel in the image weighted by how similar these pixels are to the target pixel [12]. Hence it provides better post-filtering clarity in MRI images. Non local means filter cleans the image containing noise without losing much of the significant details and edges [12].

However, the main disadvantage of non-local means filter is that then the noise increases and its performance deteriorates substantially [12]. That the noised image often suffers from the problem of blurring and there is the subsequent loss of image details [12].

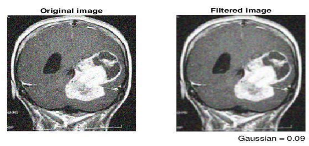
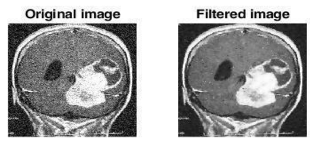
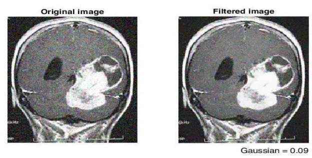
6. Experimental Results

Different datasets and MRI images were taken for the implementation of anisotropic diffusion techniques. The coding is performed using MATLAB-R2018b. Following is the implementation of filtering operation MRI brain scans corrupted by noise.

6.1 Comparative Analysis of Filter in Pre Processing Stage

Comparative Analysis of filtering techniques applied on noisy MRI images is performed and their signal to noise ratio and peak signal to noise ratio is calculated. Here MRI images are first subjected to Gaussian noise then different filters are applied to check their performance.Gaussian noise is considered because it is additive in nature and it is easier to model noise which might be introduced in MRI scans.

Table 2. Shows the comparison between noisy and filtered MRI images

Sno.	Filter Applied	Results
1.	Averaging Filter	
2.	Anisotropic Diffusion Filter	
3.	Guided Filter	

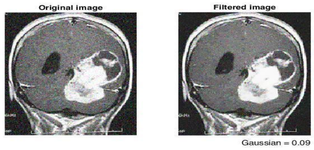
4.	Non-Local Means	

Table 3. SNR and PSNR were obtained for filtering operations on MRI images

SNo.	Filter Applied	SNR(Signal to Noise Ratio)	PSNR(Peak Signal to Noise Ratio)
1.	Averaging Filter	11.0165	17.7974
2.	Anisotropic Diffusion Filter	16.4767	22.1250
3.	Guided Filter	11.0111	17.7920
4.	Non-Local Means Filter	11.0089	17.7899

Table 3 shows the SNR and PSNR of different filters applied at the pre-processing stage. SNR and PSNR are calculated using the formulas described below.
Let AxB be the image. If original AxB image is f(a,b) and filtered image be g(a,b)
SNR is calculated using below formula[7]:

$$SNR = \sum_{i=0}^{A-1}\sum_{j=0}^{B-1} g(a,b)^2 / \sum_{i=0}^{A-1}\sum_{j=0}^{B-1} [g(a,b)-f(a,b)]^2 \quad (3)$$

To calculate the PSNR, Mean squared error is measured using the formula given below[7]:

$$MSE=\sum_{A,B}[f(a,b)-g(a,b)]^2 / A*B \quad (4)$$

Here a, b are number of rows and columns of input image.
Then PSNR is calculated using the below formula[7]:

$$PSNR = 10\log_{10}(R^2/MSE) \quad (5)$$

Here R represents the maximum fluctuation in input image datatype. For eg. for an 8-bit unsigned integer datatype R is 255. On comparing values obtained in Table 3 it can be observed that the anisotropic filter performs better in comparison to other filters.
Then anisotropic diffusion filtering is applied to perform further operations to detect brain tumours. Tumour detection was performed further using anisotropic diffusion filtering.

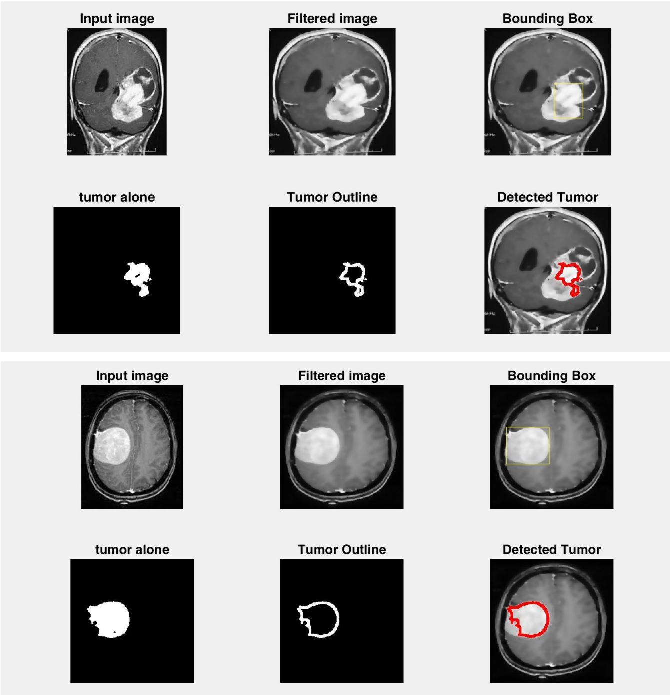


Figure 4. Tumour detection was performed on different MRI images

Figure 4 shows the tumour detected after applying an anisotropic filtering operation. With the help of an anisotropic filtering technique, detection of malignant tumour region in the reconstructed MRI image can be done.

7. Conclusion

A comparative analysis of different nonlinear filters has been done by applying these filters in pre-processing stage to reconstruct MRI images corrupted by Gaussian noise. It can be seen that techniques like anisotropic diffusion filtering when applied in pre-processing stage filter MRI images efficiently. These noise-free reconstructed MRI images help in the proper analysis of malignant tumours in brain tumour detection.

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