Brain Tumor Segmentation in MRI images using Hybrid Approach

DISSERTATION-II

Submitted in partial fulfillment of the
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By

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CERTIFICATE

This is to certify that the dissertation titled **"Brain Tumor Segmentation in MRI images using Hybrid Approach"** that is being submitted by **Urfa Mushtaq** is in partial fulfillment of the requirements for the award of MASTER OF TECHNOLOGY, is a record of bona-fide work done under my guidance. The contents of this dissertation, in full or in parts, have neither been taken from any other source nor have been submitted to any other Institute or University for award of any degree or diploma and the same is certified.

Dr. Rajeev Sharma

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Examiner I **Examiner II**

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DECLARATION

I, Urfa Mushtaq, student of M.Tech (ECE) under Department of Electronics and Communication Engineering of Lovely Professional University, Punjab, hereby declare that all the information furnished in this dissertation report is based on my own intensive research and is genuine.

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ABSTRACT

The occurrences of brain tumors are increasing so fast, especially in the older population as compared to the younger ones. Brain tumor is a mass of abnormal cells that grow in the brain or around it. Tumors gradually terminates all brain cells that are healthy and slowly cause damage to other fit cells by congesting rest of the brain. Consequently, it may cause the inflammation, brain swelling and pressure in all the skull. Magnetic resonance imaging (MRI) works on the strong magnetic field, radio frequency pulses and a system like computer to generate detailed pictures of organs, tissues, bone and in fact, all other internal body structures. It does not use ionizing waves like used in X-ray and MRI produces a detailed image of brain and nerve tissues in different planes without obstruction by overlying bones. Manual image segmentation for a single MRI scan is a laborious process which requires costly, specialized software which take long hours of work to segment a single image sequence. Therefore, in the presented work, we develop a hybrid approach for automatic segmentation of MRI head scan. The developed segmentation method is useful for brain tumor detection. As an image processing problem, medical image segmentation also poses many significant challenges due to artifacts like noisy data, low contrast images, and large variations between patients. The primary bottleneck in this workflow is to create ability to properly and efficiently segment medical imaging input data for use in simulation, modeling, as well as in statistical analysis. Hence, present research focuses on the de-noising of the MRI and subsequent segmentation of the tumor.

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LIST OF ABBREVIATIONS

MRI	**Magnetic Resonance image**
ROI	**Region of Interest**
NROI	**Non-Region of Interest**
RL	**Richardson Lucy Deconvolution**
INU	**Intensity Non-Uniformity**
PSF	**Point Spread Function**
PVE	**Partial Volume Effect**
MM	**Mathematical Morphology**
WM	**Water Method**
CSF	**CerebroSpinal Fluid**
SVM	**Support Vector Machine**
RBS	**Region Based Segmentation**

Chapter 1 Introduction

1.1 Overview

Brain is the controller of the human nervous system. It is an utmost intricate organ in the human body. A small change in brain due to damage or disease affects the processing of other organs. Occurrence of tumor, reduction of brain or an injury, shock, seizures are certain of the normally occurring disease. Neurologist require the pathological state and structure of the brain for detecting brain diseases. Therefore, imaging of the it is important to study the tissues in the brain. there are number of the modalities for imaging in existence like radiography, single-photon emission computed tomography, x-ray, ultrasonography, magnetic resonance image, positron emission tomography. Among all of these modalities MRI produces a high resolution scans of the tissues that are soft in texture in the brain. MRI is one of the mostly used test in neurology and neurosurgery. MRI scans are captured in three orientations axial, coronal and sagittal [22].

Over the last few years, the fast development of noninvasive brain imaging tools have unlocked new horizons in analysing and studying the brain anatomy and function. Enormous advancements in accessing brain injury and exploring its anatomy has been made using MRI. It is basically used to find the finer details of a particular tissue. This technique has proved to be better than computed tomography as it provides the details of tissues. MRI is meant for the tissue level diagnosis. MRI provides an effective way of non-invasive mapping of tissues [8]. It uses magnetization properties of atomic nuclei. The strong static magnetic field, a pulsed magnetic field and radiofrequency energy is used to map the tissue as a scan in particular planes [22]. The achievements in this imaging technique have also provided us with large quantity of data with a progressively high level of excellence. The analysis of this huge and complex MRI datasets has turned into a tedious and complex task for clinicians, who manually have to identify and extract significant information. This semi-automatic analysis is time-consuming and prone to errors due to various inter as well as intra-operator variability cases. These hindrances in brain MRI data analysis required development in computerized methods in order to improve disease diagnosis and testing as well. Nowadays, computerized techniques for MRI segmentation and visualization have widely been used to help doctors in analysis and diagnosis.

MRI is used to find exquisite particulars of brain, vascular anatomy as well as spinal cord, and it has the benefit of being able to envisage anatomy in the planes defined, that is, axial, sagittal and coronal. There are three kinds of images T1-weighted, T2-weighted and Flair [22]. For the brain study and for other process such as its volume estimation, registration, tumor of detection, structural knowledge, brain segmentation from MRI is required. T1-weighted images are generated by utilizing short times of TE and TR, where repetition time (TR) is time between consecutive sequences of pulse applied to the same slice and time to echo (TE) is the time between the reception of the echo signal and the delivery of the RF pulse. The brightness as well as contrast of the image are majorly quantified by tissue's T1 properties. Contrariwise, T2-weighted images are generated by using longer times of TE and TR. Tissue can also be categorized by two different relaxation periods – T1 and T2. T1, which is known as longitudinal relaxation time, is the time that decides the rate at which energized protons come back to harmony. It is taken as a measure of the time taken for spinning protons to realign along the external magnetic field. T2, known as transverse relaxation time, is the time constant which governs the amount at which energized protons reach equilibrium or the time taken to go out of phase with each other. It is a measure of the total time booked for spinning protons to shed phase coherence among the nuclei spinning perpendicular to the principle field. The contrast and brightness in these images are majorly quantified by the tissue's T2 properties. In general, by looking the CSF, T1- and T2-weighted images are easily differentiable. CSF is dark on T1-weighted imaging while as it is bright on T2-type as depicted in Figure 1.

The another frequently used sequence of MRI is the fluid attenuated inversion recovery (Flair). The categorization of flair is quite same as T2-type but in this case TE and TR times are longer. By doing so, irregularities stay as bright areas but normal CSF is weakened in view and is dark. This type is very responsive to pathology and makes the comparison between CSF and abnormality much easier [22].

Key parts of structural brain MRI examination include the organization of MRI data into particular tissue types and the identification and description of specific anatomical structures. Arrangement intends to allot to every component in the picture a tissue class, where the classes are defined in advance.

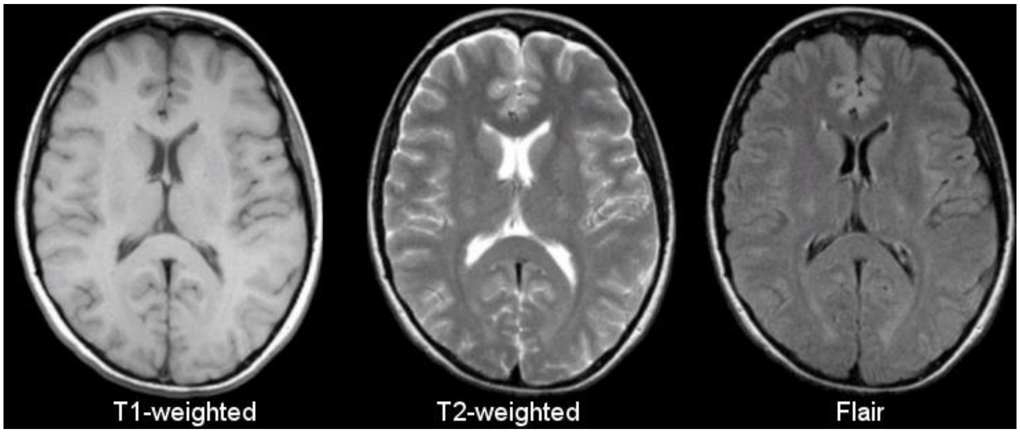


Fig 1.1: MRI sequences

Tissue	T1- weighted	T2-weighted	Flair
CSF	Dark	Bright	Dark
White matter	Light	Dark gray	Dark gray
Cortex	Gray	Light Gray	Light Gray
Fat(within bone marrow)	Bright	Light	Light
Inflammation	Dark	Bright	Bright

Table 1.1: MRI sequences comparison

The problems of segmentation and classification are interlinked as segmentation implies a classification and a classifier indirectly segments an image. In brain MRI, image essentials are typically categorized into three main tissue types: gray matter, white matter and cerebrospinal fluid. The segmentation results are further used in different applications such as for investigating functional structures, for studying pathological areas, for surgical planning, and for visualization as well. In this case of study, the segmentation of MRI is performed for identification of tumor region.

Tumor is mass of irregular and inappropriate cell in a tissue. Cells divide inappropriately and this division continues till all the cells are affected. The early diagnosis can treat this uncontrolled mass generation. Tumor is of three types [12]:

1. Benign tumor: The cancer does not abruptly spread and this, therefore, puts no threat to life.

2. Pre-malignant: It is pre-cancerous stage, which if not treated may turn into malignant one, a third type of tumor.
3. Malignant: This type is that worsens with time, grows and spreads and ultimately takes life of person.

Brain MRI segmentation is a fundamental step in many clinical applications since it affects the outcome of the entire analysis. This is on account of various processing steps depend on exact segmentation of anatomical areas. For instance, MRI segmentation is normally utilized for measuring and visualizing different brain structures, for trace lesions, for analysing brain development, and majorly for surgical planning. This assorted variety of image processing applications has prompted advancement of different segmentation techniques strategies of different accuracy and level of complexity.

1.2 Scope of study

The purpose of segmentation is to make extraction simpler and change the Figure of an image into something that has meaningful presentation and easier to interpret. Image segmentation is basically utilized to find the location of objects and curves in images. More precisely, image segmentation is the technique of labeling each and every pixel in an image in such a way that pixels with the same label have certain features in common. Therefore, the goal of image segmentation is to divide an image into certain non-overlapping regions that are inhomogeneous with respect to some attributes like intensity and texture.

As MRI gives the information regarding the functional structures and possible irregular tissues necessary for the planning of treatment and patient's follow-up, the brain tumor identification and segmentation in MRI is important in medical diagnosis. The segmentation of tumors in brain can also be useful for general demonstration of pathological brains and the formulation of pathological brain atlases. In other words, the objective of medical image segmentation can be summarized as the extraction and characterization of functional structures with respect to some expert knowledge. The MRI segmentation is useful to the radiologist in finding apprehensive things. Radiologists, though, good at interpreting images, get tired and can miss things completely. Algorithms of segmentation can help them to point to anything that might be worth to consider (tumors in this study case).

1.3 Objectives of study

MRI is trending technology and it has got promising future in identification of tumors efficiently. We have seen different kinds algorithms like region K-mean clustering, C-mean clustering, Region based segmentation method and many more which are implemented in different ways to overcome the possible problems occurring in MRI head scans. There is more complexity in most of the scans, which requires to be addressed cautiously so that tumor can be detected at early stage and thus treated on time. The MRI images are often affected by of noise (MRI artefacts), causing detection of malign tissue hard. The deconvolution is the first step carried prior to the segmentation. The noise and blurs are the concerns to be treated by the de-noising and then segmenting the early tissue or malign tissue, is the step to be worked on.

Future findings in the segmentation of medical scans will attempt in reducing the amount of manual interaction and thereby, improving the precision, accuracy, and evaluation speed of segmentation methods.

A technique called morphology-based brain segmentation has been developed for complete computerized segmentation of the brain MR image data in [5]. The initial stage is a controlled stage called supervised segmentation technique, which has been verified exceedingly powerful and exact for quantitation and representation purposes. The proposed technique mechanizes the client association, i.e., characterizing a seed point and a threshold range, and depends on the straightforward operations like thresholding, erosion, and dilation. The thresholds are identified in a region growing method and are defined by links of the brain to other tissues.

The consequences of the computerized segmentation are very likely as the supervised segmentations. Brain volume characterization in light of the computerized and supervised segmentations are precisely indistinguishable in general. In consequence, the proposed strategy can be used as a default technique of segmentation for quantitation and understanding of the human brain MRI in casual clinical methods.

There has been suggested in [6] a new technique to identify and segment brain portion from an MRI of human brain scans. They have suggested that the Richardson-Lucy (RL) deconvolution algorithm, a spread function restoration method, can be utilized to improve the detection of boundary. Point spread function(PSF) of Gaussian type is considered for this algorithm. The de-convoluted image is then exposed to binarization, erosion and dilation, largest connected area is isolated the brain portion. RL method habitually eliminates the noise and also produce high detailed image. Deconvolution is method of restoration used to obtain an image back that is affected by blurring and noise.

Medical imaging modalities like MRI, CT, PET are intricate techniques of imaging. MRI scan shows different objects like soft tissues and bony constructions along with the noise introduced in it during the process of image acquisition. Segmentation of such images is a tedious and challenging task, as separation of the different objects and noise is required to get better diagnostic results. The novel methodology presented in [7] is a two stage segmentation. In the first stage, Gabor filter are produced by using various frequencies and orientations. Region of interest (ROI) is identified in the filtered image and iterative contour detection method is applied to the image filtered, which causes the detection of different objects in the image. Segmentation is performed using discrete gray level sets.

Tumor area is extracted by threshold segmentation and it is thus analyzed for shape and size. The simulation results obtained are very promising for the identification and analysis of the brain tumor.

The two stage segmentation is useful to suppress noise and for extraction of the desired ROI. As only tumor region is extracted, it is easier to find area occupied by tumor. Contour detection helps to distinguish the boundaries and ultimately separates different regions in the image.

Combination of various modalities like MRI assumes a critical part in limiting the neuronal activities with a given dormancy. This process is referred as co-registration. In [8], a three stage methodology is mentioned to prepare raw data of MRI for co-registration. The rudimentary prerequisite from the brain MR images is the segmentation of the cortical surface of the brain. To play out this, the MR images taken in to thought, are pre-handled to take off the segments that are not some portion of ROI. The removal of noise and partial volume effect are the important preprocessing tasks. This is obtained by the applying some skull stripping method like hole-filling, dilation and erosion and subsequent anisotropic diffusion filtering of the skull free images. Marker-based watershed segmentation is then evaluation to segment the cortical surface which is then used for co-registration**.** The cortical surface is extracted from MRI. The said method uses the stripping of skulls, anisotropic diffusion filtering and then finally, the marker based watershed segmentation. It is to be underscored that the marker based watershed segmentation technique has been favored over the simple watershed segmentation as this method avoids the drawback of over segmentation, which is the case with the regular watershed segmentation technique.

The authors in [9] have focused on removal of brain tumor and its region description through segmentation from the brain MRI image. For noise removal, the pre-processing step is carried out initially. Extraction of brain tumor is performed by giving thought to the methods like morphological operations, k-means clustering and region growing. A comparative study of the three methods is performed for different brain MR images. In this work, the tumor in the MRI is referred as region of interest (ROI) and rest of the image is referred as Non-region of interest (NROI).

K-means clustering, which is having benefit of being automatic, execution is faster and has low computational density. Segmentation carried out by morphological operators is more efficient than k-means clustering because it effectively suppresses the noise and in-homogeneities due to anomalies in MR machine, however, it is semi-automatic, it gives less efficient results as compared to the third method in list, region growing method. This method, though semi-automatic, gives most accurate results among three methods. The disadvantage with this method is that the user has to choose the opening seed which need to be approximately precise. Besides, the results provided by this method take more evaluation time compared to others.

Foreground detection is important parts in the grounds of computer vision which emphases on to recognizing the fluctuations in the sequences of images and to distinct the foreground image from rest which is referred as background. It is an order of systems that typically inspects the video series gradually and are documented with a stationary camera [10]. For the early identification of brain tumor, an automated framework employing sequences held on multispectral camera, is mentioned. The camera has point of interest of acquiring the sequences at higher precision. This is performed by employing the RBS algorithm. There are two main phases; initial one involves segmentation of the input image by using preprocessing, carried by anisotropic diffusion filtering and RBS. The next stage performs the sorting process by using support vector machine (SVM) classifier, the key contribution of which is Sobel edge recognition and character extraction [10]. Methods like improved adaptive mean shift and anisotropic diffusion filtering are used. The sharpening effect are delivered by AD filtering, which eliminate the noise from an input image. Second stage performs the extraction of features and Sobel edge detection from the segmented result. Processing time is lessened by this technique and the peak signal to noise ratio (PSNR) for refined background and foreground is analyzed.

The work [11] views a relative study of three segmentation technique, realized for tumor detection. The strategies discussed are k-means clustering with watershed segmentation algorithm, optimized k-means clustering with genetic algorithm and optimized c- means clustering with genetic algorithm. Conventional k-means algorithm is prone to the original chosen cluster centers. Genetic c means and k-means clustering procedures are utilized to discover tumor in MRI. Finally, the tumor is removed from the MR image and its precise location and the outlines are determined. The c-means clustering after optimization has been found better among the methods. The problem of over segmentation was addressed. The genetic algorithm increases the convergence and reduces computing time. Other parameters like growth rate and volume of ROI can be identified to find better segmentation results and their performance.

Median filter and Gaussian filter has been used in [13] for noise removal and image sharpening respectively. In this paper the segmentation has been carried out by thresholding method. How-ever the results are checked by the watershed segmentation method. The post operations are carried out by the morphological operators. The threshold based segmentation followed by watershed segmentation prevents the over segmentation results. The morphological operations are conducted to enhance the results. These help removing the non-region of interests.

The authors in [15] have applied the primary image into two dimensional Otsu's method. It has reduced the amount of calculations to a greater extent and has a good feature. In threshold based methods, the in-between-class variance technique, suggested by the Japanese scholar Otsu's is broadly used in image processing because of its healthier segmentation results, easier calculations and extensive scope of application. On the basis of 1-D histogram, the given technique favors the largest inter-class variance between foreground and background as a basis for choosing the best segmentation threshold. In case of better quality of the image and stable change of the NROI, One-dimensional Otsu's's method can produce healthier segmentation outcomes. Since 1D histogram of image cannot specify the space-related knowledge among the pixel, it is hard to get efficient segmentation outcomes when the image noisy. Due to this requirement, Liu Jianzhuang [16] et al. developed the 2D histogram. This consists of the pixel gray-level distribution and neighborhood average gray-level distribution. When the 2D technique searches for the finest threshold, it requires to pass through entire 2D histogram, and perform a deal of mean calculations in its rectangular area, however, it is very easy to calculate on the basis of integral image which can elude the traverse of the region.

In [17], authors have mentioned mathematical morphology (MM)and watershed method (WM) that are hybridized to attain an efficient and reliable outcome of extraction of the tumor. The proposed approach follows three phases. The first preprocessing phase is meant to enhance brain MRI images. This stage involves the segmentation process or the implementation of approaches MM and WM. The fusion phase which is last phase, accounts for the extraction of tumor zone. In preprocessing stage, the image is improved by eliminating existing noise and enhancing the finer details. The median filter has been utilized because it is less prone to outliers. The value of pixel is evaluated by the median of the neighboring pixels. For the contrast, improvement has been obtained by using

Gaussian filter, which improve the borders of the structures in the image. After enhancing, morphological operators are used to retain the useful information. The two elementary morphological operators, erosion and dilation have been used. Opening and closing are other two consequential operations from the basic erosion and dilation. These operators are based on some structural element. The watershed segmentation is applied to the scans and the last part combines the outcomes obtained from morphological operators and the watershed method to detect and extract the tumoral zone from MR images.

In [18], study of segmentation of brain MRI for the purpose of defining the exact location of brain tumor has been presented using cohesion based self merging (CSM) based partitional k-means clustering algorithm. Clustering theory is that to establish data in such a way that it forms clusters. The clusters are represented such that there is high intra cluster resemblance and low inter cluster resemblance. Informally natural clustering among objects have been found. It is an unsupervised learning method in machine learning. It is a strategy which automatically partitions data set into k number of independent groups. Initially, randomly 'k' number of centroids from initial data set are selected. The different k regions in the image are attained, however, the tumor region is still not predicted. To detection tumor region, CSM method is used as the measurement of the inter cluster likeness. The clusters that are similar, are merged and the non-similar ones remain unmerged, supposing that the tumor region has a different attribute which makes it non-similar cluster among all tissues. Since, it take into consideration all the data points while judging the similarity of the two sub-clusters cohesion is more accurate for an inter cluster similarity measure. This method is based on the combination probability of two clusters referring to the existence of a data point. All the similar groups are merged into one and the non-similar ones remain unmerged, after assuming that the tumor region has a different attributes which makes it different from the non-tumor tissues.

To extract tumor from image this study has applied the mathematical morphology to remove noise. Erosion is the morphology based method, used to reduce the noise in the context of diminishing the size of image from its original size and the way image is shrunk is resolved by the structuring element. In this study, authors have applied binary mathematical morphology. Hence converting images into binary ones. The dimensions of the structuring element is governed by on the size of image.

Brain tumor detection using meta heuristic algorithms has been performed in [19]. The automatic segmentation of brain tumor from magnetic resonance images described a gradient-based brain image segmentation using Ant colony optimization and block based technique. It follows the real ant colony behavior. A hybrid of Ant colony optimization and Fuzzy logic produces a segmented Brain MRI. From Markov Random Field method, labels are created and Posterior energy function are calculated for every image pixel. Minimum Posterior energy function is searched in algorithm while in, the Fuzzy algorithm is used to find the optimum label for segmentation. To use this method, the optimization problem is changed into the problem of discovering the preeminent path on a weighted graph. The artificial ants incrementally construct solutions by tracing over the graph. The solution construction process is stochastic and is influenced by a pheromone, that is, a number of factors associated with graph constituents the values of which are improved at runtime by the ants.

The study carried out in [19] also entails an effective registration framework which uses block based technique. The technique uses standard patient's image and compares it with reference images. In block based technique, the given reference MRI and the standard image are divided into number of blocks. Each block of each images is 64 ×64. In total, 16 chunks the image are distributed into. After blocks are created, bi-lateral subtraction is carried out between the given images. This so computed value is then compared with the threshold already taken, in this procedure. Then initial chunk from both the images are subtracted and the average value of the pixels in given chunk are evaluated. This value is then paralleled this threshold value. If any of value crosses this limit, that patient's particulars will be stockpiled in the database as a suspicious case. The method is, therefore, grounded on average intensity evaluation for chunks of both standard and target image was calculated and compared. The doubtful cases are directed to the abnormal database, otherwise to normal database.

In the present work [20], Otsu's segmentation technique called between-class variance is taken along the firefly algorithm. Firefly algorithm, which is a nature motivated metaheuristic method, was initially suggested by Yang. The methodology was formulated by copying the blinking illumination patterns fashioned by glowworm and firefly. These produce chemically generated light from their lower abdomen. The bioluminescence with different blinking arrangements generated by firefly is utilized to develop communication between neighboring fireflies, to look in for target and to discovery mates. The conditions taken under consideration here are:

1. All the fireflies are of same sex.
2. A firefly will be enticed to the nearest firefly regardless of their sex and the appeal between two fireflies is measure of the luminance.

The main factors which find the efficiency of the is algorithm are the changes of light strength and appeal among the neighboring fireflies. These two elements are affected by the rise in the distance between fireflies. The projected histogram centered exploration method helps in decreasing the computational time.

2.1 Problem statement

In overall Tumor identification and segmentation, there are many factors which affect the image quality and hence the diagnosis. There are different conditions which cause the images to blur. Movements in patient body introduces the artifacts that can cost life sometimes. So the focus of this research work will be identifying the noise in MRI head scan. The purpose will be solely to rectify the artifacts like noise and then properly segmenting the tumor. Couple of data sets will be worked on so that the results come out properly and efficiently. The results should be better than provided this far by other procedures. Hence when good results are obtained, accuracy will increase and robustness will too. So the research will proceed like, firstly the deconvolution will be carried out to find the pixel intensities properly and secondly the segmentation of the affected area will be done.

The methodology opted here will be followed up as given:

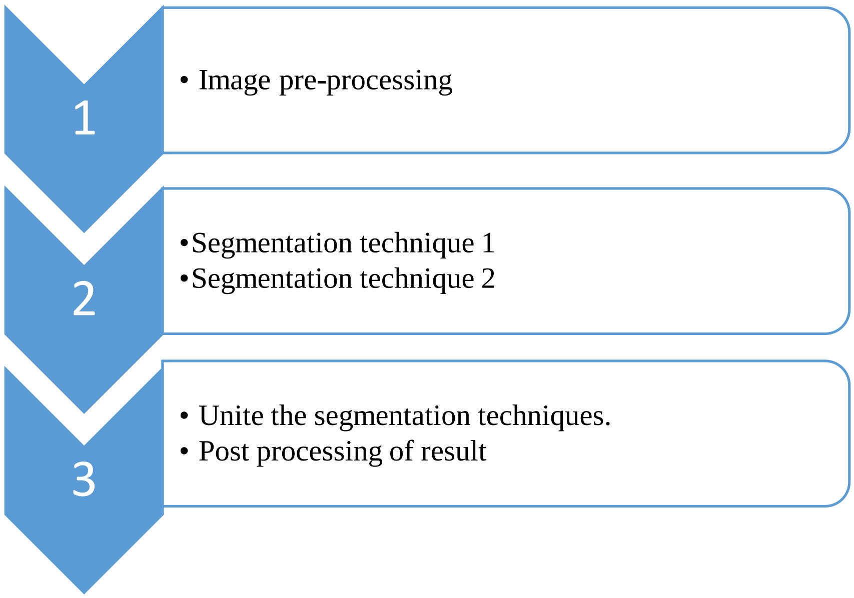


Fig 3.1: Methodology

The method followed for the segmentation is hybrid method of segmentation. The various methods of segmentation have been observed. There are different kinds of artifacts like point spread function, partial volume effect etc which lead to the poor diagnosis. Removal of an artifact will be treated in the preprocessing. The segmentation of the tumor area will be the next step followed. The segmentation will make the scan an image of non-overlapping regions. Since the focus of this study is hybrid segmentation technique, two or more segmentation techniques will be worked on. In post processing step, the skull pixels and unwanted regions will be removed to produce refined region of interests.

The individual segmentation technique does not produce a favorable result, therefore, the two or more techniques are technically collabrated to produce results with combined features of technique. The combination of the techniques to segment the tumor area in the MRI scan will be finalized once all the methods are observed for the results. The methods combined will provide the better segmentation results compared to the individual methods. In many cases of the segmentation, the results show up the over segmentation or the under segmentation of the area. Such problems are under consideration for the correction.

3.1. Deconvolution

The resolution of an acquisition tool is often limited so that the acquired image of the sample is majorly hooked on the properties of the device. Blurring in images comes from the strength of pixels at any point in it being approximately weighted sum of intensities from all points in the ROI space. The noise causes opacity in the image renewal (deconvolution) process so that more than one ideal restoration solution exists with no a priori method of determining which solution best represents the real object. Deconvolution is a calculated transformation of image data that has been reduced out of focus light or has been somehow blur. Recent deconvolution procedures work around some of these limitations, often by making a number of sensible assumptions about the object like the smoothness and embrace extra data about the noise process itself [1].

Blurring has remained cause of image degradation in wide field fluorescence microscopy. It is random and comes from within the ocular train and specimen, and is comes majorly as a consequence of diffraction. An evaluated model of the obscuring which is grounded on the convolution of a point object and its PSF, can be used to de-convolve out of focus light back to its point of origin. Blurring is always there, to some extent, in all imaging methods, like photography, vision and medical Imaging methods. The basic concept of blur is illustrated in the following Figure 3.2. An image is a visual representation of a particular physical thing that exists, like a patient's body. In an ideal case, each point within the image object would be Figured by a small, well-defined point within that image. However, in reality, the image of each object point is spread within the image which is called blurred one.

The major cause of image artifacts like blurring is patient's movements. There are two types of motions that create artifacts:

- Arbitrary movements which yield a blurry and noisy image, mostly in the phase-encode direction.
- Episodic motion which forms ghost images in the phase-encode direction.

Movement artefacts normally spread in the phase-encode direction. This is because of the between phase-encoding and signal reading or movement of the spins between two excitations: in the foremost case, their phase-encoding will not be correct., in the second case, the spins will not be recorded at the similar site between excitations.

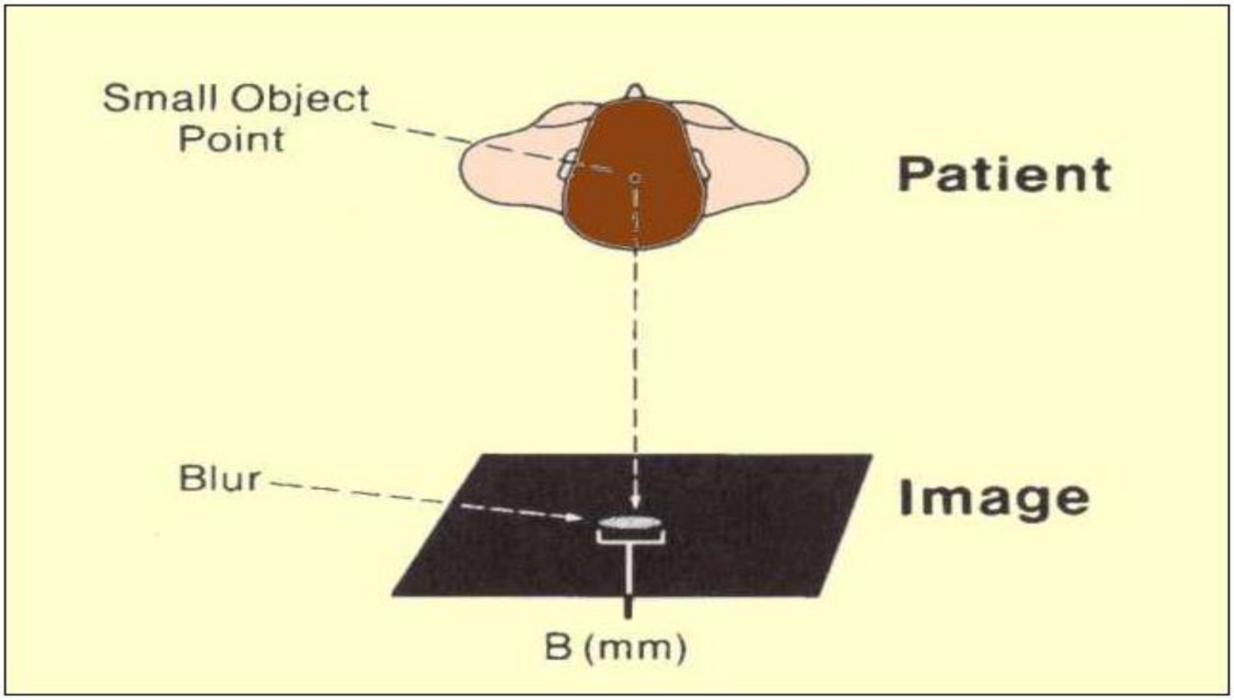


Figure 3.2: Blurring medical image

The motions which are periodic, like due to arterial, cardiac beats, pulsations, respiration, continue propagating in the phase-encode direction. They can generate the ghost like images. The pixel strength of these ghost images turns more and more extreme with the increasing intensity of the moving object and with the amplitude of motion. These ghost like images can appear as an increase or decrease of the true image signal. The gaps between ghost images changes along the direction of the motion, amplitude and periodicity relative to the phase-sampling interval.

Partial-volume effects are artefacts which take place because of several tissue types contributing to a particular pixel, causing an obscuring of intensity strengths across boundaries. Figure 3.3 illustrates the result of partial-volume effects which has caused an ambiguities in structural definitions.

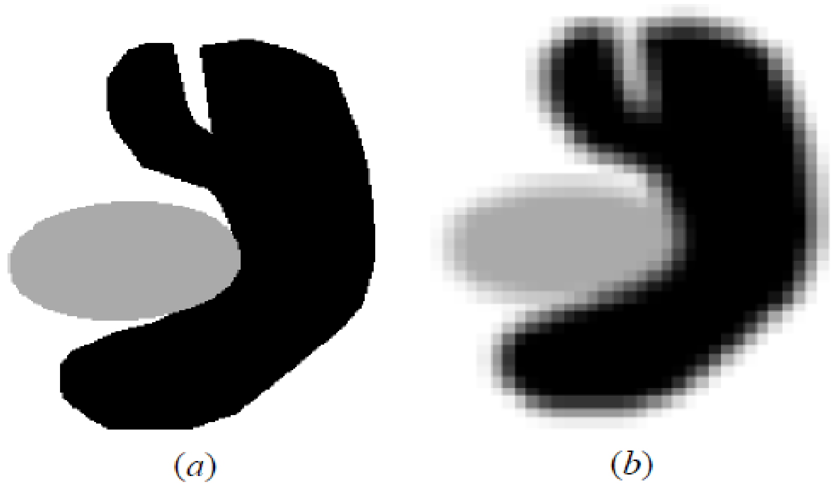


Fig 3.3: Illustration of partial-volume effect. (*a*) Ideal image. (*b*) Acquired image.

In Figure 3.3(b), it is not easy to precisely decide the borders of the two objects. These effects are usual in medical images, especially in case of MRI images, where the resolution is not isotropic and, in some cases, is quite poor along one axis of the image. As the restoration techniques were not fully developed earlier, the weak resolution was ignored. But with the advent of techniques to address partial-volume effects, as well as advancement towards higher-resolution, techniques helped to handle the situation.

Point spread function (PSF) is an another artifact majorly seen in MRI images. The point spread function is a property of magnetic resonance imaging technique that degrades the image quality and spatial resolution. The actual PSF is the 3D diffraction arrangement of light radiated through an infinitely minute point source in the sample and directed to the plane of image via a high numerical aperture (NA) objective. Through such point source, when light gets emitted, the portion of this light is additively collected by an objective. The objective later subjects this portion of light to the plane. However, the emitted light is not focused by objective lens small point in the image plane entirely. Rather, light waves meet and disturb at the focal point to generate a diffracted arrangement of concentric rings of light neighboring a central, bright disk, when observed in the x-y plane. The illustration of the PSF is given in Figure 3.4.

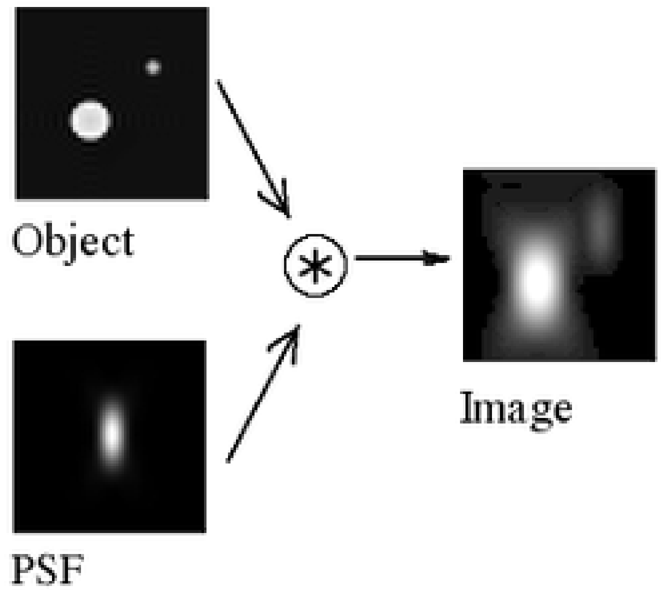


Fig 3.4: Illustration of PSF

The commonly used approach to address partial-volume effects is to get segmentations which allow regions overlapping, called soft segmentations. The general approaches used are hard segmentations because they enforce a binary decision for if a pixel is inside or outside the ROI. Soft segmentations, however, sustain more information from the input image by approving for uncertainty in the location of object outliers [14].

Intensity non-uniformity in MRI is an artifact that is easily observable. The common cause are imperfect electromagnetic field interacting with internal inhomogeneous body components, eddy currents etc. The primary cause of INU in MRI is spatial variations in the sensitivity of the radiofrequency coil. This results into smooth gradation of signal intensities in image. These variations degrade the numerical analysis of the neuroimaging data. Physical interaction between scanner and tissue is also the reason for the artifact and thus cannot be eliminated.

Significant amount of work has been carried out over the concern of on image de-noising methods. The methods already in play are able to produce better results in many practical areas. The various de-noising techniques are as follows:

3.1.1. Spatial filtering: A customary approach to expel noise from scan information is to utilize spatial filters [1]. This sort of filtering is frequently used to clear-out the output of lasers, evacuating distortions in the beam due to flawed, damaged optics. These filters can be additionally characterized into non-linear and linear filters.

a) Linear filters: Under the linear filters, the time-varying input signals, are processed to produce output signals and are then subject them to the linearity. Linear filters have tendency to blur sharp and high frequency edges, therefore, destroying lines and some of the fine image details. These filters also perform poorly in case the signal-dependent noise is present in image. The linear filter, wiener filter, requires the spectral knowledge of the noise and the input signal and it does not work well in case the primary signal is not smooth. Wiener method performs the spatial smoothing, the window size of which is chosen as per the model of filter.

b) Non-linear filters: Non-linear filters have many applications in removing the non-additive kind of noises. Normally the spatial filters de-noise the image to a reasonable extent but blurr the images which results into edge invisibility. In these years, a number of nonlinear median type filters have been established such as weighted median, rank conditioned rank selection.

3.1.2. Mean filter: A mean filter follows up an image by smoothing it; that is, it caused decrease the intensity among neighbouring pixels. The mean filter, which is sliding window, works by replacing the center value in the window with the mean of all the neighboring pixel values counting the value of the pixel under consideration. Images that are despoiled with salt and pepper noise are subjected to mean filtering and it can be thus, seen that the noise ruling in image is reduced. The black and white pixel values of the salt and pepper noise are changed such that they become closer to the pixel content of the adjoining pixels. The brightness of the original image remains same as the use of the mask, coefficients of which sum up to the value one. This filter is utilized in applications where the artifact in certain sections of the image are required to be removed.

3.1.3. LMS adaptive filter: For non-stationary images, adaptive filters are capable of denoising the noise, where non stationary images are images that have hasty changes in intensity. Such filters are famous for their tendencies of repeatedly tracking an unfamiliar circumstance [2]. The least mean square adaptive filter is known for its simplicity in evaluation and implementation, therefore, adaptive filter are preferred for de-noising images compared to the averaging filter. This filter also works well for images affected with salt and pepper type noise.

3.1.4. Median filter: The median filter is similar in the way of moving kernel principle to the mean filter. A 3×3,5×5, or 7×7 windows of pixels are scanned over the matrix of pixels in the whole image. the window is evaluated for the median value. Once the value has been obtained the central value is replaced by that value. This process iteratively takes place, till all the valves in the frame are replaced by the corresponding medians. This filter is faster than the mean filter. Thus, a single exceptionally unrepresentative pixel in an area won't influence the median value fundamentally. Since the median value should really be the estimation of one of the pixels in the area, the median filter does not make new unlikely pixel. For this behavior the median filter is considered much superior at conserving high frequency edges than the mean filter. These merit of this filters aids it in de-noising uniform noise as well from an image.

3.1.5. Spatial median filter: The spatial median filter is also noise removal filter where the spatial median is ascertained by figuring the spatial profundity between a point and an arrangement of point. In this filter subsequent to finding out the spatial depth of every point lying within the filtering mask, this knowledge is utilized to take decision whether the central pixel of kernel is corrupted or not. If the so pixel is un-corrupted then there will be no change. Spatial depth of each pixel is then calculated and these spatial depths are in descending order. The point with highest spatial depth is taken as the spatial median of the set.

3.2. Segmentation

Image processing plays a vital part in imaging science, in the analysis and understanding of images in fields related to medical discipline, navigation, environment, computerized event detection, surveillance, texture and pattern recognition. The advancement of digital imaging methods and automatic technology increase the capability of imaging science. During the image processing operation, a photograph or a video frame is analyzed with a chosen signal processing technique and the outcomes such as processed image, data, and/or parameters related to image are further investigated to obtain the desired knowledge from the raw input image. Image segmentation is one of preprocessing methods used to regulate the characters of an image. It is also considered to be an important method for fundamental examination and understanding of input images.

In the past decades, automatic image segmentation has played a vibrant role in medical imaging. Segmented images are now-a-days utilized on regular basis in a multitude of applications, such as the, diagnosis, localization of pathology, quantification of tissue volumes, study of anatomical structure, treatment planning, partial volume correction of functional imaging data, and computer-integrated surgery. Image segmentation is a difficult task to handle because of the tremendous variability of ROI shapes and the changes in image quality. Image segmentation is most important task in medical image analysis. It is generally the first and the most crucial step in number of clinical applications. In brain MRI analysis, image segmentation is generally utilized to measure and visualize the brain's structures, for visualizing brain variations, for eroding pathological regions. It has also find application in surgical planning. In these years, number of the segmentation strategies of different accuracy and complexity have been developed in the literature.

The purpose of image segmentation is to segment an image into a set of meaningful and non-over-lapping areas of same attributes like intensity or depth. The results of this process is either an image of labels recognizing each homogeneous region or a set of boundaries which illustrate the region boundaries. Certain segmentation techniques have been described below:

3.2.1. Thresholding

Thresholding [4] is majorly used method for segmentation as this method has proved to be effective for images with varying intensities. By using this technique of segmentation, the image is divided directly into different non-overlapping regions based on the intensity values.

It has been is defined mathematically as:

Let f (a, b) be the original image taken as input and ‘k’ be the threshold value then the segmented image g(a, b) is given by,

$$g(a, b) = \begin{Bmatrix} 0 \; if \; f(a,b) > k \\ 1 \; if \; f(a,b) < k \\ \end{Bmatrix} \quad (1)$$

Using Eq. (1), the image can be divided into 2 groups. If the requirement is to segment the given image into multi-groups the multiple threshold points are established and used.

If we have two threshold values, then the above equation becomes as Eq. (2) and this equation segments the image into three groups

$$g(a, b) = \begin{Bmatrix} a, if \; f(a,b) > k \\ b, if \; f(a,b) = k \\ c, if \; f(a,b) < k \end{Bmatrix} \quad (2)$$

3.2.2. Global thresholding

Global thresholding method takes single threshold for the entire image. it is used for bimodal images. It is simpler and faster in evaluating and therefore, takes less time, if the image has homogeneous intensity and there is a high contrast between ROI and NROI.

3.2.3. Otsu’s method

Wang Hongzhi formulated improved threshold based image segmentation method called the Otsu’s method [4].. The technique ensures that the variance of the ROI in image and the variance of the NROI remain away from the variance of the whole image. The advanced method gives much satisfactory results for the image with histogram of bimodal as well as unimodal distributions [4].

Otsu’s method is the generally utilized thresholding technique. Otsu’s method is simple yet effective to implement. This technique, based on a discriminant analysis, partitions the image into two classes C1 and C2 at gray levels ‘n’ such that C1 = {0,1,2,3,… n} and C2 = { n+1, n+2,…, L-1}where, ‘L’ is the total number of gray levels of the image. however, disadvantages of this method:

1. Otsu’s method has proved to be helpful in segmenting the larger objects from background only.
2. Otsu’s method also fails in case the histogram is unimodal or close to unimodal model.

3.2.4. Region growing method

Region growing strategy is one of the well-known division techniques. This technique begins with a seed pixel and develops the area by including the neighboring pixels based on threshold value. At the point when the development of a district stops, another seed pixel which does not have a place with some other area is picked and the procedure is rehashed. The area development is stopped when all pixels has a place with some locale. Region growing segmentation is specifically used for delineation of small, simple structures such as tumors and lesions. The various limitations in using this method are,

1. Manual interaction is required to select the seed point in semi-automtic case of segmentation, which is a normal case.
2. Since it is sensitive to noise, it produces holes and causes over segmentation in the obtained regions.

3.2.5. Watershed segmentation

Watershed segmentation method is utilized when the foreground and the background of the image can be detected clearly. This algorithm has proved to be helpful in capturing weak edges. However, selection of initial seed point is the main limitation of this method, making it fail in similar case as region growing method. Selection the seed point randomly in certain cases lead to inappropriate outcomes and therefore, hikes the convergence rate. In this segmentation, an image resembles a surface, in which the bright pixels are assumed as mountain peaks and dark pixels as valleys. Some valleys have perforations which cause slowly merging into water and then it starts to automatically fill up the valleys. But if water comes from different perforations, it is not allowed to mix. So, the dam is constructed at contact areas which let dams work as contours of water and image objects.

3.2.6. K means clustering

K-means clustering algorithm is considered the simplest but unsupervised learning method that solves clustering problem. The process followed by this method, used to characterize a given data set through a number of groups, is very simple. In K-means 'K' centres are identified initially, one for each cluster. The clusters are placed far away from each other. The step next followed is to pick a point belonging to a given set and join it to the center nearer to it. Finally when no point is available for association, the initially step is finilised and early grouping is performed. The next step is to recalculate ‘k’ centroids as new centroids of the new clusters resulting from the previous step. After having ‘K’ new centroids a new association has to be performed between the data set points used earlier and the new nearest center. A loop is established. By using this loop, the k centres change their place step by step till centers do not move any more. K-means algorithm has been enlisted in the fast and robust list of techniques and also easier to understand. It also performs well and thus provides the better result, especially when data set are quite separated from each other. However, if there are two highly overlapping regions then k-means falls weak and does not perform well, it fails to resolve that there are two clusters.

3.2.7. Edge based segmentation

Edge based segmentation techniques divide an image based on abrupt changes in intensity near edges The result is, therefore, a binary image. Based on theory this includes gradient based method.In gradient based method, the two neighbouring pixel are considered and difference between them is evaluated. The difference value is considered. Therefore, if there is a sudden change in intensity near boundary and there is small image noise like blurring then this method works well. This method works on the criteria that gradient operator is convolved with the image. General edge detection operators used in this method are Sobel operator, Canny operator, Laplace operator, Laplacian of Gaussian operator and so on, the canny is considered the most promising one, however, it takes more time when compared to Sobel operator.

Edge detection methods needs a proper balance between detecting accuracy and noise susceptibility. when the level of identifying accuracy is much high, noise brings in fake edges making the outline of images not reasonable and when the quality of noise immunity is too excessive, in that case some parts of the image outline get undetected and therefore the position of objects may be mistaken. Thus, edge detection methods are best for images that are simple, noise-free as well. To detect boundaries between two distinct regions, edge based segmentation is used [4].

3.2.8. Ant tree algorithm

The Ant tree technique was specially introduced for MRI brain image segmentation. However, the general Ant- Tree technique cannot be utilized in MRI Brain segmentation directly. The Ant-Tree algorithm establishes a hierarchical pattern in an increasing manner in which the ants associate together. In this method of segmentation, each and every ant is considered as a single datum from the data set and it moves in the structure as per the similarity with the other ants which have been already connected in the tree under construction. For the partition of the whole data, a more accurate decision is made while considering the place in which each ant will be connected, either to the main support or to another ant.

In improved version of this algorithm, the tree structure of the algorithm makes sure that the new ants don't require to search the whole data set when they are connected to the structure. Generally, each sub-tree is connected to the support as a group. Therefore, the hierarchical pattern of the tree has a large number of redundant knowledge. For this problem to be solved, a new technique of cluster center was introduced in order to improve the tree model of the ant tree algorithm. In Li Chenling *et al*. introduced this version of technique and proved advanced ant tree clustering algorithm can generate results better than k-means and FCM. Besides, the evaluation speed of the improvised algorithm is much faster than the other two clustering algorithms.

3.2.9. Deformable models

Medical images are generally corrupted by noise and artifacts, which cause accountable problems while applying conventional segmentation methods like edge finding and thresholding. Therefore, these techniques fail thoughroughly or they need some sort of post-processing step to remove NROI boundaries in the segmentation outcomes. To remove these difficulties, deformable models were thoughroughly studied and used extensively in therapeutic image segmentation, with efficient results. Deformable models are curves or boundaries demarcated in an image which can be displaced under the effect of internal and external forces. The internal forces are the forces which are defined under the curve or under the surface itself while as the forces calculated from the image data are known as external forces.

Under any deformity, the internal forces play role of smoothener while as the external forces are accountable for the movements of modal towards the curves within scan. These models are motivated physically, delineating techniques for region borders using closed parametric surfaces that reshape under the effect of internal and external forces. For removing an object edge in image, a closed curve or surface should initially be positioned near the required boundary and then made to undergo an iterative process. For keeping the deformation smooth, the internal forces are calculated within the surface. External forces are obtained from the image to drag the curve or surface towards the desired feature of interest.

Deformable models have been used for segmentation of medical images widely. These have been majorly used in the rebuilding of the cerebral cortex from MR images [13]. The main merit of using the deformable models are that these generate closed parametric curves or surfaces straightly from images and their generation of a constraint corresponding to smoothness gives robustness to noise and spurious edges. Manual interaction requirement is yet again the disadvantage.

3.3. Expected outcomes

The purpose of this study is to automate the method of segmentation for MRI scan after noise removal. MRI provides an effective way of non-invasive mapping of tissues. It is commonly utilized in radiology for visualization of the structure and function purpose. It generates the very comprehensive scan of the human body in all direction. Specifically, MRI is helpful in neurological, oncological, and musculoskeletal imaging as it offers much greater divergence between the soft tissues of the body compared to the CT. MRI differs from CT by not using ionizing radiation, but it uses an operative magnetic field to align hydrogen atoms in water in the body. Over the past three decades, as most research has exposed, the death rate of people affected by brain tumor has increased [22]. Brain tumor is one of the most dangerous illnesses up in human, so to study brain tumor is very critical.

An image segmentation method is utilized to detect the tumor from the brain MRI. Several thresholding methods that are in existence, have generated diverse result in each image. Therefore, to produce an efficient and accurate result on brain tumor images, time to time number of techniques have been proposed. This part of study will be focused on the hybrid technique of segmentation. Before the segmentation is performed, the scans will be treated by a de-convolution technique to remove the particular degradation from the scan in case present. The results will show the tumor areas as non-overlapping areas in image. The regions will be out segmented to be identified as tumor. The method is working on to find approximate area of the tumor sections in brain MRI scans. The results can be utilized for diagnosis, planning the treatment, monitoring therapies, surgery and pathological brain modeling.

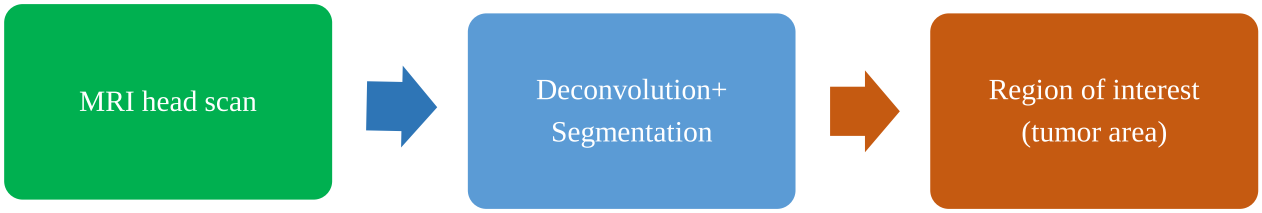


Fig 3.5: Outcome of methodology

3.4. Proposed work plan with timelines

The proposed plan will follow up as given

- Literature review
- Problem identification
- Restoration
- Segmentation
- Report making

3.4.1. Literature review and problem identification

The literature review has already been completed as it has been running for hole of this semester. The literature survey was conducted over the brain MRI segmentation for the segmentation of the tumor. There have been implemented a lot of the techniques till date. However, the segmentation of tumor is yet the challenging task. The tumor identification and thus segmentation has been paid much attention from years. Each technique carries the merits as well as demerits along itself. The techniques at certain cases cause the over segmentation and at times the under segmentation is the case. Pixel homogeneity between the affected area and other brain portion in MRI scans has been responsible for the weak segmentation. The segmentation results are meant to be used for the diagnosis and treatment, costing human lives. Beside the segmentation problems in the RI, there have been identified the cases where the MRI scan was not clear. The reason behind the non-clarity was found certain artifacts that are introduced into the scan while acquisition majorly. Therefore, the purpose of this study is to restore the MRI scan, identify the tumor region and thus segmentation of the approximate areas from the scan.

3.4.2. MRI restoration

The artifacts are responsible for the improper identification, leading to the wrong diagnosis. The restoration or the deconvolution method for our study will be finished first. The timeline occupied by this study will be till 15 February, 2018.

3.4.3. Tumor segmentation

By the end of the March, the method of segmentation will be finished to be worked on. Since we are working on the hybrid method, more than one techniques are needed to be worked on.

3.4.4. Report writing

Month of April will be dedicated to the file making.

	Jan 2018	Feb 2018	March 2018	April 2018
Image restoration	To be done	To be done		
Tumor detection & segmentation		To be done	To be done	
Report				To be done

Table 3.1: Timelines

In this part of study, this paper [6] was implemented through which the work will be proceeded further. The paper has mentioned the use of Richardson Lucy deconvolution method to remove the point spread function effect in the MRI scan. The segmentation technique used after correcting the artifact was the Otsu’s’s method of thresholding. Morphological operators have been used post segmentation to improve the results.

4.1 Otsu’s method of thresholding

The objective of the implemented paper is extraction of brain out of the MRI head scan of human, therefore, an MRI image of perfect brain was taken here initially. The Point Spread Function(PSF) was introduced into the image so that to follow the deconvolution procedure as mentioned in [6].
The image after being affected by PSF has been treated by the deconvolution method called Richardson Lucy deconvolution. The Richardson–Lucy algorithm, which is also called as Lucy–Richardson deconvolution, is an iterative process for restoring a artifectal image that is distorted by a known PSF. The PSF is the 3D bending pattern of light outsend from an precisely minute point source in the specimen and sent to the image plane through a high numerical aperture (NA) objective. When light is produced from such a point object, a part of it is taken by the objective and directed to a corresponding point in the image plane. But, the objective lens does not direct the emitted light to small point in the image plane. It is rather converged and interfered at the focal point to obtain a diffraction structure of concentric rings of light as shown in Figure 4.1.

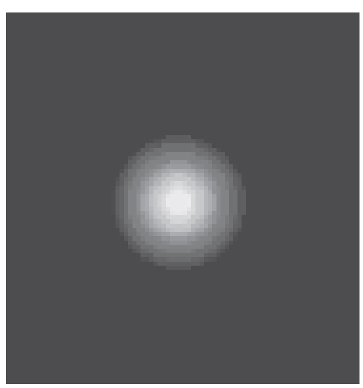


Fig 4.1. Point spread function

For the extraction of the brain from scan Otsu's method of segmentation is used. The result has skull intact to the region of interest, therefore the post processing has been conducted, where in the disk shaped structuring element was utilized for the erosion. Erosion removes the external skull pixels in result. Since after segmentation, a number of region are segmented, but the brain is ROI, therefore the areas are evaluated. The segment with largest area which accounts for the brain in this case is chosen and thus taken into account. This is region of interest. The structuring element utilized in the erosion step does not work similarly on every image, therefore the radius or the dimensions need to be changed as per the image requirement.

The image after being affected by PSF has been treated by the deconvolution method called Richardson Lucy deconvolution. For the extraction of the brain from scan Otsu's's ethod of segmentation is used. The result has skull intact to the region of interest, therefore the post processing has been conducted, where in the disk shaped structuring element was utilized for the erosion. Erosion removes the external skull pixels in result. Since after segmentation, a number of region are segmented, but the brain is ROI, therefore the areas are evaluated. The segment with largest area which accounts for the brain in this case is chosen and thus taken into account. This is region of interest. The structuring element utilized in the erosion step does not work similarly on every image, therefore the radius or the dimensions need to be changed as per the image requirement. Since in the implemented paper it was to segment the portion of the brain, therefore, the Brain area was segmented. This approach can however be utilized to obtain the Tumor area of the brain if present. The results of such image have been shown below. This, however, do not work on images having kind of homogenous pixel intensity in both the regions. The segmentation of the tumor section in brain MRI head scan has been given below, where the tumor has been segmented out.

4.2 Region growing method

Region based technique lies on the postulate that all surrounding pixels within the one region have same value or a particular range. The general process is to compare a particular elemental feature of one pixel to all its neighbour(s). If homogeneity is conserved, then pixel is classified to the same class as one or more of its neighbours. However, the choice of the homogeneity feature is critical for even mild success and in all examples the results are upset by noise. The problem with the region growing method is that the method is semi-automatic. The initial seed is chosen by the user. This intervention is considered the de-merit to this method, however the results are found the certain. Thus this method has been given much importance in many study cases.

4.3 Fuzzy c-means

FCM is an unsupervised algorithm for segmentation that is established on the notion of finding cluster centroids by repeatedly adjusting their location and calculation of an objective function. The repeative optimization of the FCM algorithm is actually a local searching method. This method is largely used to minimize the distance among the input image pixels in particular clusters and maximize the same between cluster centers time. FCM algorithm has long attained the popularity among the image segmentation methods. However, the algorithm works on the assumption that similar points in feature area must be grouped together to form a cluster. The procedure is prone to noise. Therefore, misclassification chances are more in case if the present. This is an procedure that specifically considers the minimization the cost function. Cost function or objective function of the process characterizes the distance of pixel from the cluster centers. The pixels through which various regions of the image are formed, are interconnected naturally. Therefore, the neighboring pixels show same featured information. The conventional boundary tracing method excellently uses the spatial knowledge for segmenting regions of interest. FCM, however, has the capabilty to cluster large data sets, but it fails badly when it comes to handle INU problem [21].

4.4 K-means clustering

K-means clustering algorithm is considered the simplest but unsupervised learning method which is a potential cluster. The process tailed by this method, used to characterize a given data set through a number of groups, is very simple. In K-means ‘K’ centers are identified initially, corresponding to each cluster. The centers chosen are located at different positions, far away from one another. The step next followed is that pixel is considered and the upon evaluating the objective, it is joined to the center nearer to it. Finally, when no point is available for association, the initially step is finalized and early grouping is performed. The next step is to recalculate ‘K’ centroids as new centroids of the new clusters resulting from the previous step. After having ‘K’ new centroids, a new association has to be performed between the data set points used earlier and the new nearest center. A loop is established. Iteratively this loop is utilized and the ‘K’ centers keep changing their place step by step till centers do not move any more. K-means algorithm has been enlisted in the fast and robust list of techniques and also easier to understand. It also performs well and thus provides the healthier result, especially when data are quite separated from each other. However, if there are two highly overlapping regions then K-means falls weak and does not perform well, it fails to resolve that there are two clusters.

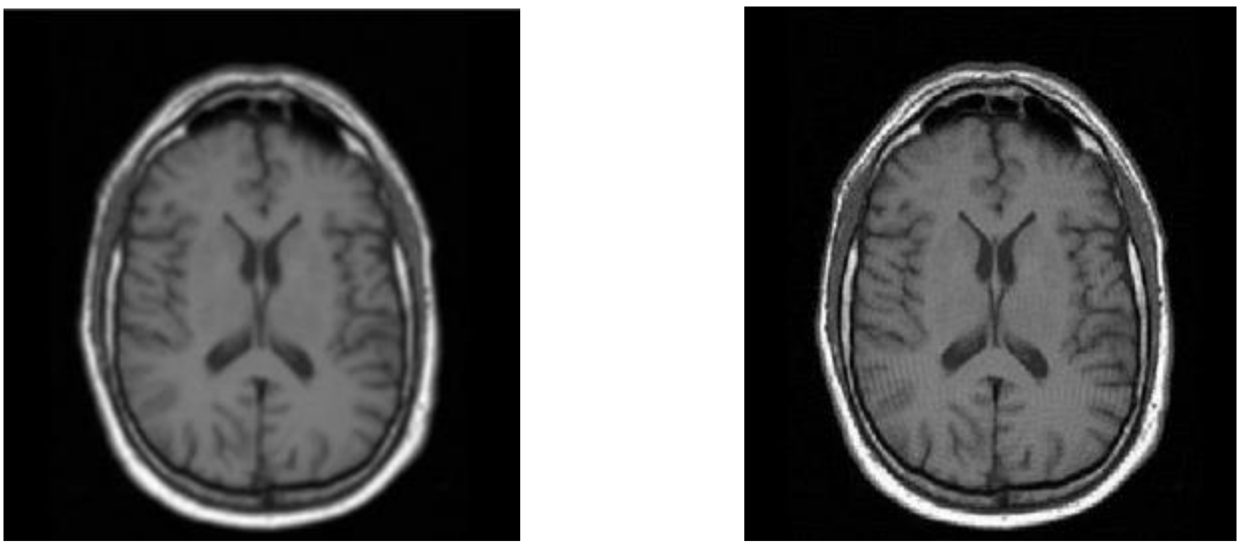
4.5 Database

The MRI images used in results were obtained from online portal MEDPIX. The portal provides free medical images and clinical topics. The content material is arranged in by location (organ system) of disease; category of pathology; patient profiles; and, by image classification and image captions. The collection in portal is searchable by patient symptoms and signs, diagnosis, organ system, image modality and image description, keywords, contributing authors, and many other search options.

The other source of the date base has been hospital, Shri Maharaja Hari Singh Hospital (SMHS), located in Srinagar, Jammu and Kashmir. The scans where provided by Dr. Umer Mushtaq, working as a surgeon in the hospital since last 4 years.

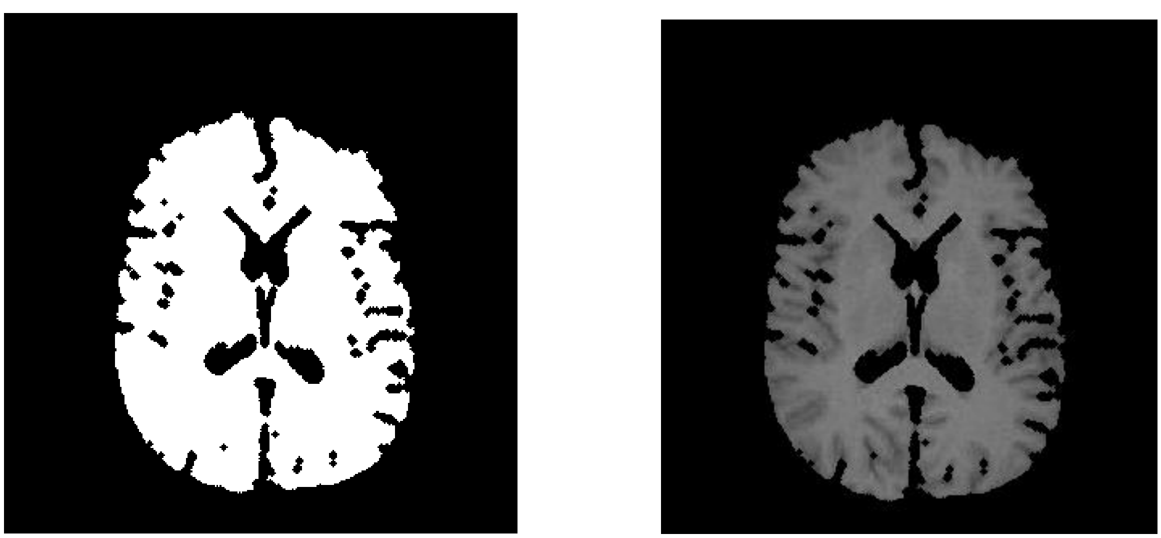
5.1. Results and Discussion

The implementation of Otsu's's method of segmentation after MRI being processed by the Richardson-Lucy deconvolution has been shown in Figure 5.1 and 5.2. As the purpose of the implementation was overall brain identification and segmentation, therefore, the MRI was chosen of the brain without any diagnosis.



(a) (b)

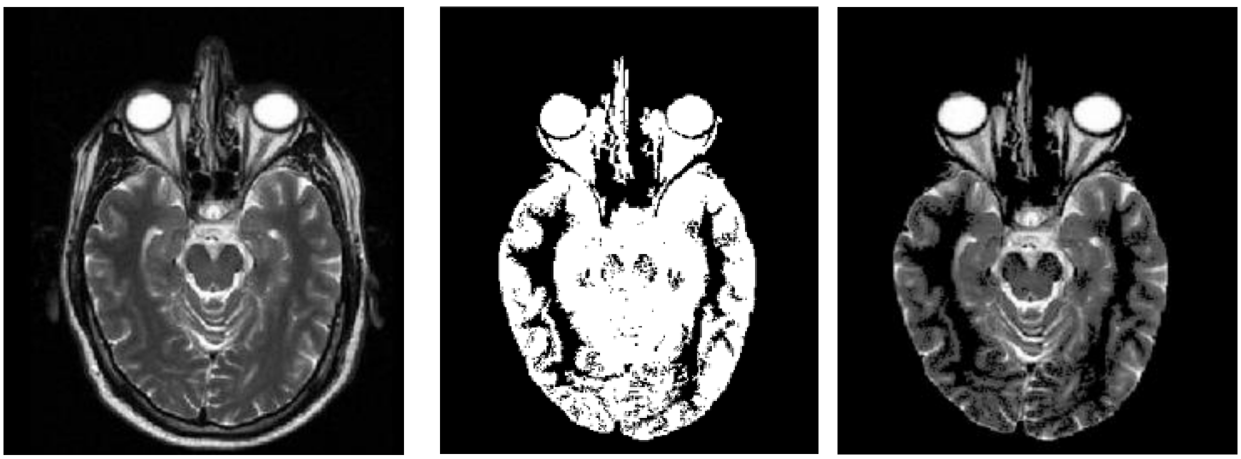
Fig 5.1: a) PSF affected MRI of brain, (b) RL de-convoluted image of (a).



(a) (b)

Fig 5.2: a) Segmented brain from fig 4.1(a), (b) Grayscale result

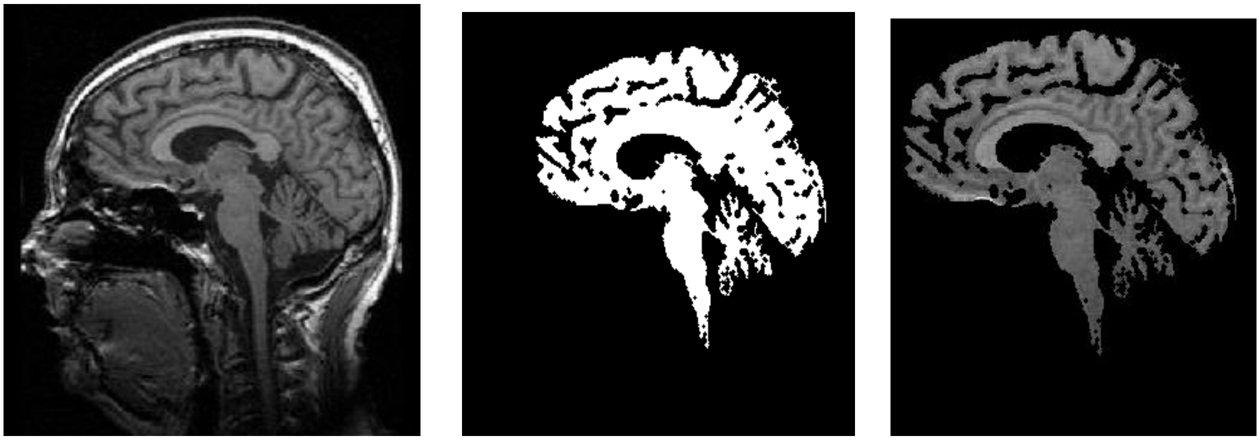
The MRI was simple, therefore, the brain was segmented correctly. The image taken next (fig 5.3(a)) for the segmentation is an axial MRI of human brain. the MRI has shown the eyes intact with the head. During segmentation, the eyes were segmented along the brain portion as well. This revealed that the implementation has this as a limitation. The intensity inhomogeneity makes the implementation to suffer. The structuring element, taken disk here, radius for Figure 5.3 was initially 1,2 and more, the results were not satisfying. The eyes in result were removed but ROI was eroded to much extent. The final radius used was disk of 0 radius which equals to no erosion at all. The results obtained can be seen in Figure 5.3.



(a) (b) (c)

Fig 5.3: a) Original MRI b) Binary segmented brain image c) Grayscale image

Similar was the case with sagittal MRI taken below in Figure 5.4(a). The Figure shows the segmentation results when the disk shaped structuring element with radius 1 was used. The brain was segmented though but the erosion caused erosion from ROI, reducing the area of the ROI. However, the Figure 5.5, no erosion was applied. The method of segmentation segmented the brain in the MRI but the skull was not removed properly. The method however, does not help much this scan here. This implementation requires the structural element's dimensions in erosion to be changed with changing scan. Same radius of disk shaped structuring element does not work for every scan. The radius of structuring elements used for the given images have been given in the table 5.1. In Figure 5.6, the case was similar. The homogeneity in intensities have played their part and the region of interest was accompanied by the pixels and region from non-region of interest.

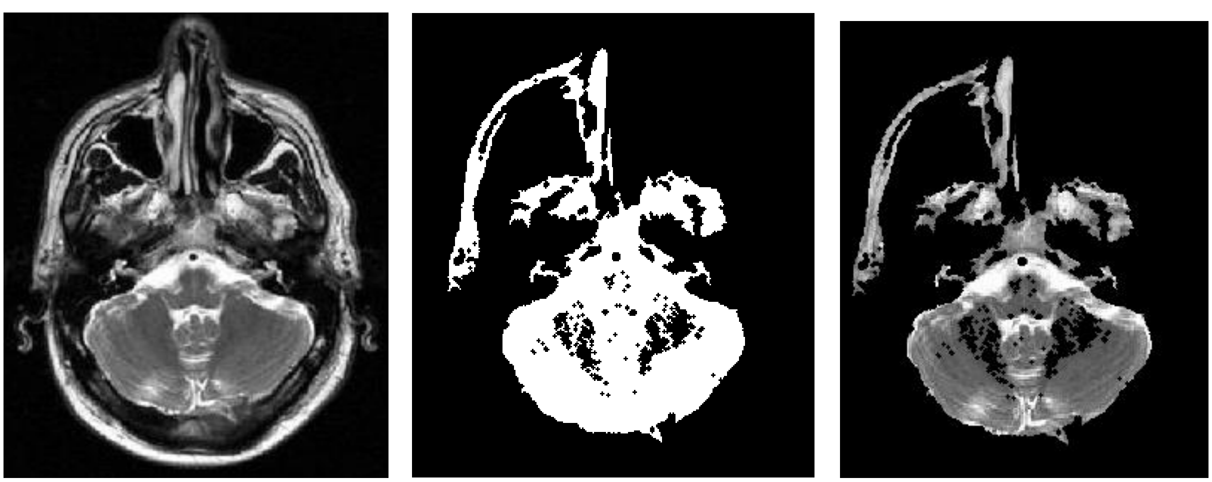


(a (b) (c)

Fig 5.4: a) Original MRI, b) Binary segmented brain image, c) Grayscale image

(a) (b)

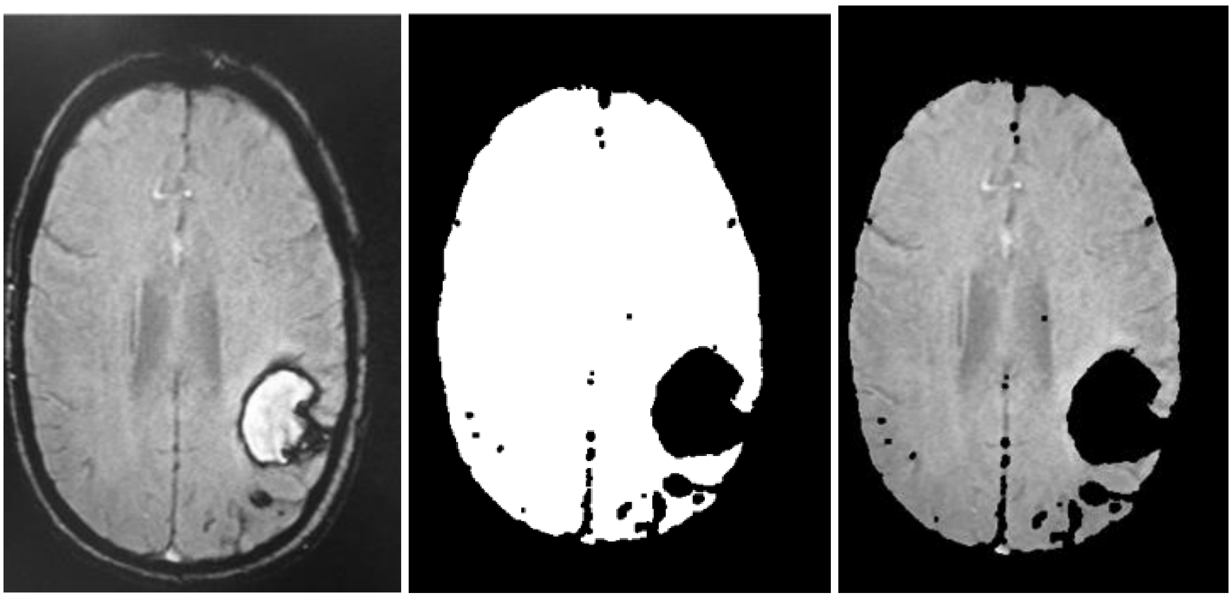
Fig 5.5: a) Binary segmented brain image, b) Grayscale image



(a) (b) (c)

Fig 5.6: a) Original MRI b) Binary segmented brain image c) Grayscale image

However, the method is applied to the images carrying the tumor areas, the results are good enough in that case as well. The largest area still remains the brain, therefore the segmentation of the brain in that case was not difficult. Figure 5.7 shows the segmentation carried out for the MRI carrying the tumor region intact. The brain yet remains the largest area while segmenting, therefore, the method worked well on such scans as well.



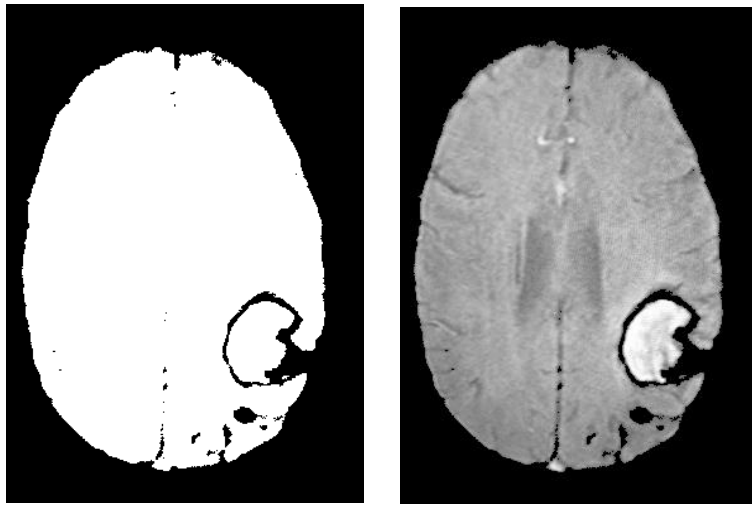
(a) (b) (c)

Fig 5.7: a) Original MRI b) Binary segmented brain image c) Grayscale image

The structuring element, disk, with radius 6 was taken for Figure 5.7. The erosion caused the tumor totally removed. When the radius was reduced to 0, the tumor was only demarcated, resulting tumor detection instead of brain extraction. The result is shown in Figure 5.8. The results resemble the results of region based technique of segmentation, given in Figure 5.13 if complemented.

Figure number	Fig 5.1	Fig 5.3	Fig 5.4	Fig 5.5	Fig 5.6	Fig 5.7	Fig 5.8
Structural Element radius	Disk, 2	Disk , 0	Disk, 1	Disk, 0	Disk, 1	Disk, 6	Disk, 0

Table 5.1: Structuring element radius effect



(a) (b)

Fig 5.8: (a) Binary image,with radius 0, (b) Grayscale image

Since in the implemented paper it was to segment the portion of the brain, therefore, the brain area was segmented. This approach can however be utilized to obtain the Tumor area of the brain if present. The results of such image have been shown in Figure 5.9 and 5.11. This, however, do not work on images having kind of homogenous pixel intensity in both the regions. The same problem affects the region of interest in case of tumor segmentation. The image taken in Figure 5.9 has a pixel inhomogeneity, therefore, the tumor was segmented properly.

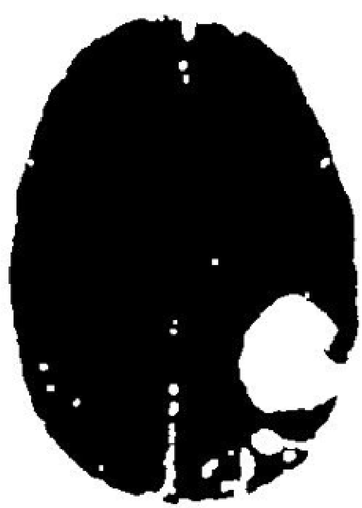


Fig 5.9. Tumor detection with Otsu'smethod

The segmented result are converted to grayscale and is presented in Figure 5.8 below.

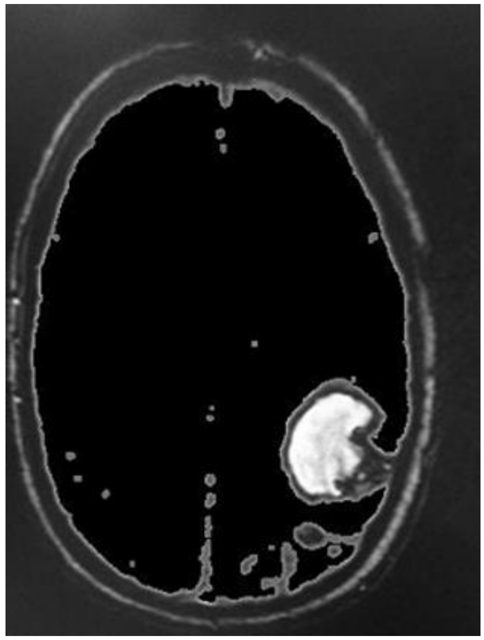


Fig 5.10: Gray scale result

Fig. 5.11: Original image

Fig 5.12: Tumor segmented area

The methods other than thresholding were also inspected. The region growing method of segmentation is semi automatic method, which needs a human intervention at the time of the seletion of the seed. This intervention is the limitation of this segmentation, which otherwise, is a favourable method of segmentation in case of the noise input.Figure 5.13 shows the result of the region growing method of segmentation of the same image taken earlier. The implementation has clearly outlined the tumor section in MRI scan.

K-means is an another method counted in the semi-automatic and supervised methods of segmentation majorly. The initial k centers are chosen randomly by user sometimes and sometimes, it is automatically taken. In the given image, the number of the clusters to be segmented were given as 2 at initial point. The image visibley has The result has properly demarcated the tumor region in scan. The method segmentation is shown in Figure 5.14 below.

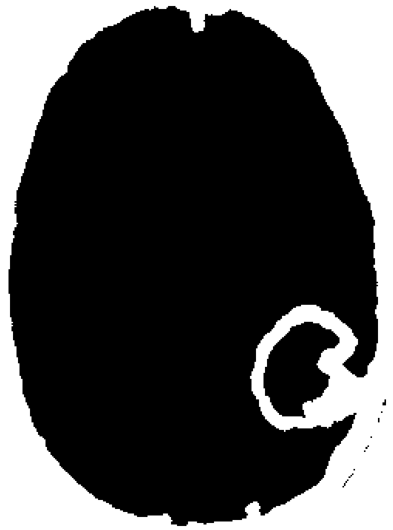


Fig 5.13: Tumor demarcation using region growing method

K-means algorithm has been enlisted in the fast and robust list of techniques and also easier to understand. It also performs well and thus provides the better result, especially when data set are quite disjoint. However, if there are two highly coinciding regions then k-means falls weak and does not perform well, it fails to resolve that there are 2 clusters. The other image from data base was tested for the k-means segmentation as shown in Figure 5.15 and 5.16. The tumor area has been properly segmented.

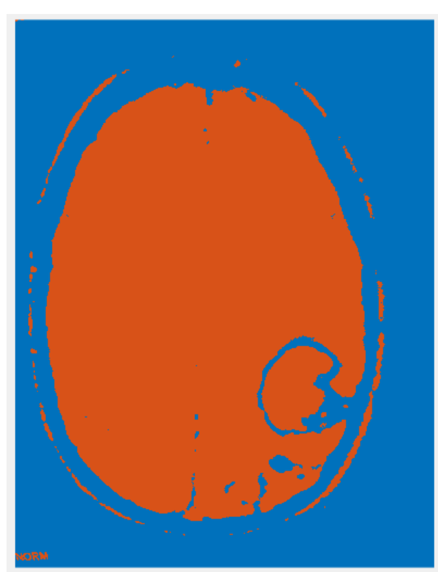
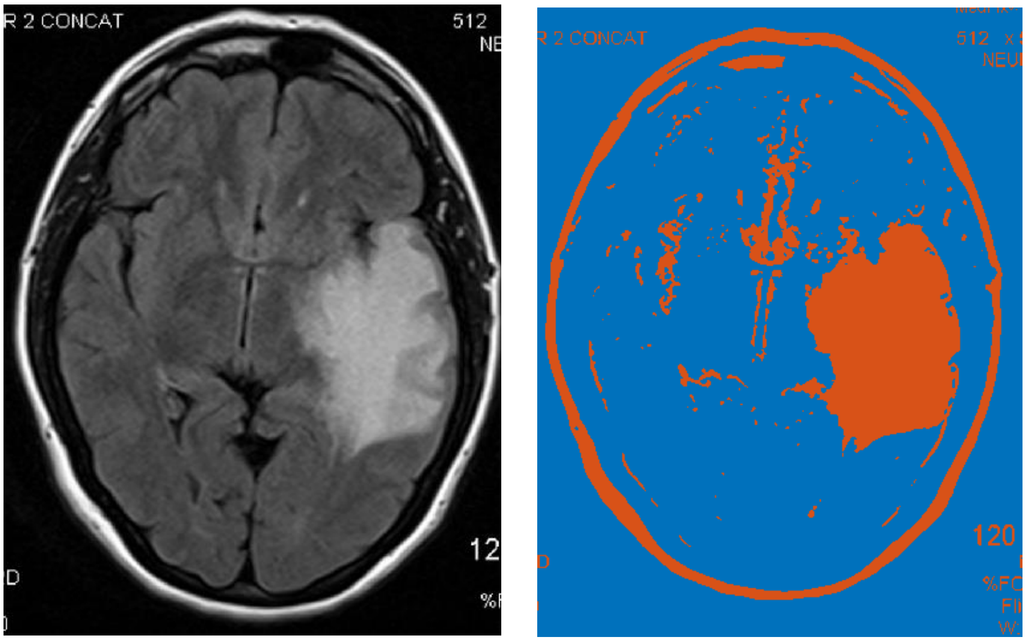
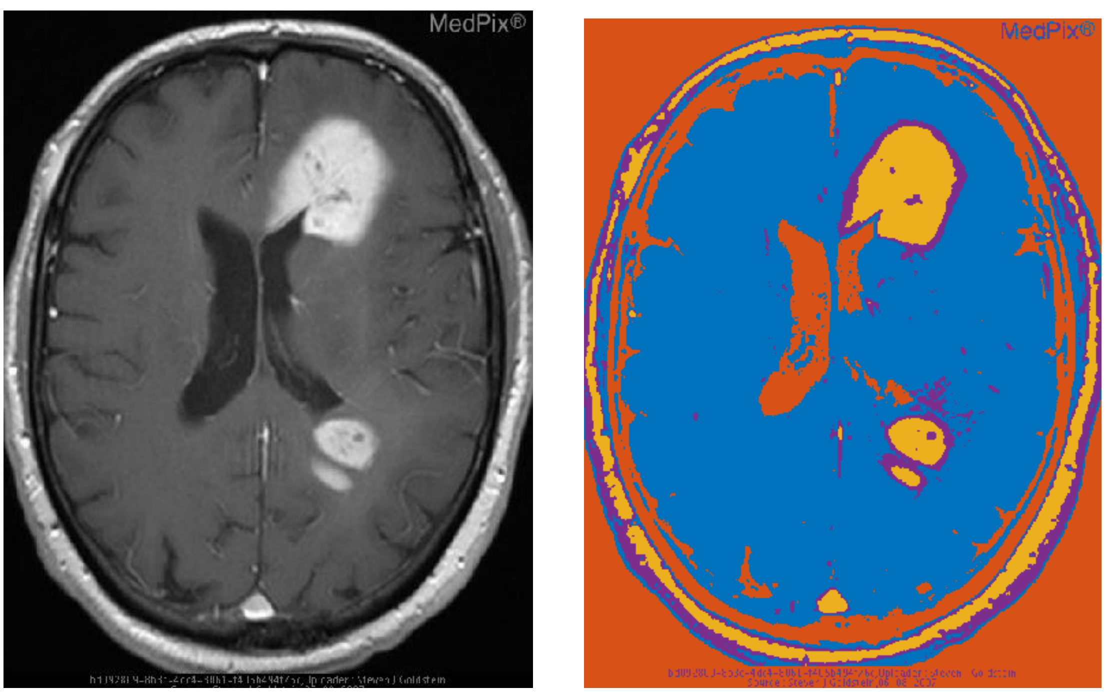


Fig 5.14: Tumor demarcation by k-means clustering



(a) (b)

Fig 5.15: a) Original image b) K-means segmented image



(a) (b)

Fig 5.16: a) Original image b) K-means segmented image

Fuzzy c-means is another clustering method which segments the regions in image. the method has been implemented and shown in Figure 5.17, 5.18 and 5.19. The Figure 5.18 and 5.19 have intensified the tumoreas in case of the pixel intensities, indicated the ROI of interest.

Fig 5.17: Tumor detection by FCM

Fig 5.18: FCM segmented MRI given in 5.13 (a).

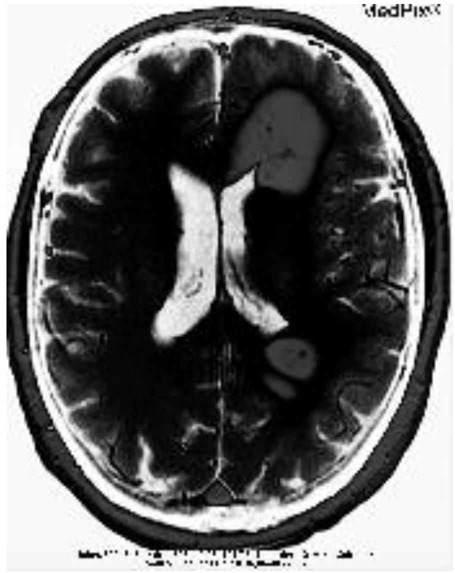


Fig 5.19: FCM segmented MRI given in 5.14 (a).

FCM clustering method and unsupervised technique for the data segmentation. The algorithm dedicates membership to each point concerning to each cluster center, basis on the space between the bunch center and the data point. The membership is higher if the pixel is closer to the cluster. The algorithm provides with best outcome for overlapped data, overcoming the drawback of the general thresholding methods and comparatively provides better outcomes than k-means algorithm. The main drawback of FCM is:

1) The membership values of pixels, if summed up, equals to one. The highest degree of membership value in the set corresponds to the cluster to which the resemblance is maximum. So the algorithm has problem in handling outlier points.

2) the results are not satisfying in case the noise is present because of varying degrees of membership, the pixel tends to attract to every center. Therefore, the pixel clarity lacks.

Chapter 6 Conclusion

6.1. Conclusion

The implemented method has proposed an optimal 2-D Otsu's algorithm, to search the optimal threshold for medical image segmentation. The Richardson-Lucy deconvolution was used to remove the point spread function artifact from the scan. The literature review of the segmentation methods has been provided. The outcome of the methods implemented underwent the over or under-segmentation, therefore, it was seen that no observed method efficiently segments the tumor from MRI images. The medical image segmentation, which could save the human life, is not fully developed area of research. The imprecise results are not worth the inference. Every method has advantage over other method but the other factors like over or under segmentation make methods less worth to trust on.

The results were seen to be affected by the noises that are inherent in the scans, for instance partial volume effect, pixel homogeneity etc. The preprocessing in these images is inevitable stage. The selection of the type of de-noising and de-convolution methods need study of the noises, mostly affecting MRI and then their remedies.

The Otsu's method was used initially to study the tumor detection. The results were good but fails in case of the homogeneity of pixels in image. The region based method observed was faster in evaluation but the method needs human interaction for the seed selection. Similar was the case with k-means clustering, which needs the initial centers to be chosen. K-means method of clustering was faster and the pixel homogeneity drawback of the Otsu's case was overcome. The method fails when the objects to be segmented in image are disjoint. The overlapping sections are taken as one, which causes false segmentation. The overlapping objects can however be identified as individual objects by using the fuzzy c-means method of operation. The drawback of this method is that due to the membership degrees, the centers tend to fall in every cluster.

No method gives a precise result thus the survey favors the Hybrid methodology. The major focus of our work is to segment the tumor section of the affected brain by hybrid method of segmentation. The method is developed to give improved segmentation results compared to the results provided by the individual methods of segmentation. The methods can be utilized based on their advantages and disadvantages. The methods, in case of the demerit, can be the complements of each other, thus, providing the better performance.

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