

An Overview for Tumor Detection and Segmentation from Brain Magnetic Resonance Image

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Abstract: Magnetic Resonance Imaging (MRI) is widely used to detect and evaluate various brain conditions, including bleeding, abnormalities, infections, vascular disorders, and tumors. In particular, MRI plays a significant role in the initial identification of brain tumors. When an MRI scan indicates the presence of a tumor, further investigations are conducted to determine its type, location, and extent through tumor segmentation and analysis. A brain tumor is an abnormal growth of cells within the brain or spinal cord that can interfere with normal neurological functions. Brain tumors may be classified according to their cellular characteristics and whether they are benign or malignant. Accurate identification and segmentation of tumor tissue from normal brain tissue remains a challenging task in clinical diagnosis. This study reviews various traditional and emerging techniques for brain tumor detection and segmentation reported between 2020 and 2025. Finally, an assessment of recent innovative approaches for brain tumor detection and segmentation is presented.

Keywords: Brain Tumor, Magnetic Resonance Imaging (MRI), Image Acquisition, Preprocessing, Image Enhancement, Image Segmentation, Fuzzy C-Means Algorithm.

I.Introduction: Over the past decade, significant advancements have been made in brain imaging technology, resulting in the development of numerous techniques, methods, and approaches that are more sophisticated than those available in previous decades. Among these techniques, Magnetic Resonance Imaging (MRI) is considered one of the most effective methods for brain image processing and analysis. MRI systems use magnetic fields and radio waves to acquire large amounts of data and generate detailed, high-resolution images of brain structures.

The analysis and segmentation of brain images from MRI datasets is a highly complex task for medical specialists, particularly when the required information must be extracted manually. Manual examination can be time-consuming and may lead to inaccurate results due to variations in expertise, experience, and training. To overcome these limitations, advances in computer technology have contributed significantly to the development of automated and semi-automated

techniques for disease diagnosis and medical image analysis.

Currently, various computational methods are available to assist clinicians in performing MRI brain image preprocessing, enhancement, segmentation, feature extraction, feature selection, and classification. This paper reviews several widely used approaches for brain tumor detection and segmentation from MRI images. Magnetic Resonance Imaging (MRI) has become a standard non-invasive technique for the diagnosis and assessment of brain tumors over the past few decades (Subhashis Banerjee, 2017). Although MRI and radiology are relatively recent developments compared with traditional medical specialties, they have become essential components of modern healthcare and clinical diagnosis.

In this study, the major techniques used for brain tumor detection are reviewed based on their methods, accuracy, performance, advantages, and limitations. The review is organized into four major stages: (1) **Image Preprocessing and Enhancement**, (2) **Image**

Segmentation, (3) Feature Extraction and Selection, and (4) Classification (K. Selvanayagi et al.). The overall structure of the proposed tumor detection process is illustrated in **Figure 1**, which presents the essential steps involved in the analysis and detection of brain tumors from MRI images.

II. Literature Survey

Brain Tumor MRI Preprocessing and Enhancement: Literature Review (2020–2025)

Magnetic Resonance Imaging (MRI) is one of the most important imaging modalities for brain tumor diagnosis because it provides high soft-tissue contrast and detailed anatomical information. However, MRI images may contain noise, intensity non-uniformity, motion artifacts, low contrast, and variations caused by different scanners and acquisition protocols. Therefore, preprocessing and image enhancement are important initial stages before tumor segmentation, feature extraction, and classification. Recent literature from 2020–2025 shows a gradual shift from conventional filtering and contrast-enhancement methods toward deep-learning-based image correction and enhancement.

2020–2021: Conventional preprocessing and enhancement During the early part of the review period, brain tumor MRI studies commonly employed preprocessing operations such as noise removal, intensity normalization, skull stripping, contrast enhancement, and image resizing. These operations were intended to reduce irrelevant information and improve the visibility of tumor regions before segmentation or classification. A systematic review of research from 2020 onward notes that denoising, intensity correction, skull stripping, and normalization remain important components of MRI preprocessing pipelines.

Traditional filtering techniques, including median, Gaussian, Wiener, and non-local means (NLM) filters, have been widely considered for reducing noise while preserving important anatomical structures. Intensity normalization is particularly important because MRI does not have a standardized intensity scale across scanners and imaging protocols. Consequently, techniques such as Z-score normalization, min–max normalization, and histogram matching have been adopted to make image intensities more consistent. DOI

2022: Emergence of deep-learning-based MRI enhancement

A significant development during 2022 was the increasing application of deep learning for MRI image enhancement and correction. Chen et al. reviewed deep-learning methods for MRI post-processing and identified three major enhancement areas: artifact correction, denoising,

and resolution enhancement. Deep learning demonstrated potential for improving MRI quality while reducing artifacts and preserving diagnostically relevant structures. Compared with conventional filters, deep-learning approaches can learn complex relationships between degraded and high-quality images. This development was particularly important for brain tumor analysis because excessive smoothing during denoising may remove tumor boundaries and small structural details. Therefore, modern enhancement methods increasingly focus on maintaining diagnostically relevant information while improving image quality.

2023: Evaluation of MRI enhancement techniques

Amgothu (2023) presented a review of brain MRI image enhancement techniques and emphasized preprocessing operations such as artifact removal, skull removal, noise reduction, and image-quality enhancement. The study compared different enhancement approaches using quantitative measures such as Peak Signal-to-Noise Ratio (PSNR), Mean Squared Error (MSE), and Root Mean Squared Error (RMSE). The review reported that different enhancement techniques perform differently depending on the dataset and clinical requirements.

The literature during this period indicates that no single preprocessing method is universally optimal. Conventional methods can be computationally simple and effective, but they may have limitations in preserving fine tumor boundaries. This encouraged researchers to investigate adaptive and learning-based techniques that can enhance contrast while retaining important anatomical features. **2024:** Advanced denoising and contrast enhancement, In 2024, researchers increasingly investigated adaptive and hybrid preprocessing techniques. For example, a study on brain MRI denoising proposed an adaptive masking strategy combined with a modified non-local block. The method was evaluated using brain tumor MRI data and reported improved PSNR and SSIM compared with conventional denoising approaches, demonstrating the potential of advanced learning-based methods for reducing noise while preserving image structure.

Another 2024 study investigated bidimensional empirical mode decomposition, anisotropic diffusion, and morphological operations for noise reduction and contrast enhancement in brain tumor MRI images. The enhanced images were subsequently used for tumor detection using Fast C-Means clustering and classification through ensemble learning. This demonstrates the continuing relevance of hybrid approaches that combine traditional image-processing techniques with machine-learning algorithms.

Contrast normalization also received attention in 2024. A proposed MRI tumor-analysis pipeline used Wiener filtering for noise removal, Principal Component Analysis (PCA) for enhancement, and Fuzzy C-Means (FCM) for segmentation. Such approaches demonstrate that conventional preprocessing methods continue to be useful, particularly in systems where computational simplicity and interpretability are important. Importantly, recent evidence also challenges the assumption that more preprocessing always produces better segmentation. A 2024 study reported that deep CNN and vision-transformer models did not necessarily benefit from bias-field correction, denoising, or harmonization. Skull stripping improved Dice scores in the examined experiments, but its effect on tumor-volume measurements was limited. These findings suggest that preprocessing should be selected according to the characteristics of the dataset and the downstream model rather than being applied automatically. 2025: Deep learning, normalization and robust preprocessing By 2025, MRI preprocessing had become increasingly integrated with deep-learning-based brain tumor detection, segmentation, and classification pipelines. Recent reviews describe the growing use of CNNs, transformers, attention mechanisms, transfer learning, and ensemble architectures for brain tumor analysis. At the same time, intensity normalization, denoising, skull stripping, and image standardization continue to be important preprocessing components.

The literature also emphasizes that MRI data obtained from different hospitals can vary substantially because of differences in scanner manufacturers, acquisition protocols, magnetic-field strengths, and patient characteristics. Such variations can reduce the generalizability of AI models. Consequently, normalization and harmonization have become increasingly important for developing robust models that can operate across institutions. Recent reviews further indicate a transition toward architectures such as nnU-Net and transformer-based models, particularly for tumor segmentation. Nevertheless, preprocessing remains an important consideration because inconsistent MRI quality can affect the performance and reliability of these models.

Summary of the literature

Period	Major preprocessing/enhancement approaches	Main objective
2020–2021	Denoising, skull stripping, normalization, filtering, contrast	Remove noise and irrelevant

Period	Major preprocessing/enhancement approaches	Main objective
	enhancement	information
2022	Deep-learning-based denoising, artifact correction, resolution enhancement	Improve MRI quality while preserving structures
2023	NLM, contrast enhancement, artifact removal, skull removal	Improve tumor visibility and image quality
2024	Adaptive denoising, anisotropic diffusion, morphological enhancement, PCA, Wiener filter	

Magnetic Resonance Image (MRI)

MRI scan is favorable one in medicinal world for initial detection of brain tumor disorder. Yet, the fault of detecting brain tumor disease with MRI images performed by radiologist. But in some hospitals, it is still manual in some places. It certainly requires a long process as well as complex due to the density of the structure of the human brain. Obviously, the slow process of detecting and ordering brain tumor disease in patients can basis delayed medical treatment for the patient's recovery. For this reason, based on the need for medical information needed by doctors to treat patients speedily and exactly, an image processing technique or method for reading MRI images is established before few decades. The intention of the detection method is to assist the radiologist in detecting tumor in medical images. In this paper review shows various techniques or methods that have been used to detect brain tumors on MRI images. It expects to provide information on different techniques or methods related to brain MRI. In this paper suggested to encapsulate and match the methods for brain tumor detection through Magnetic Resonance Image (MRI). In particular necessary steps are deliberate and related.

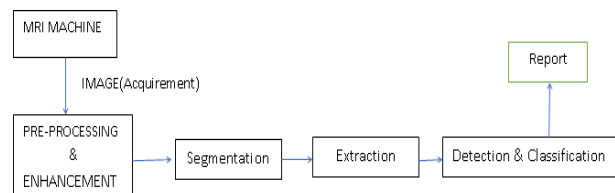


Fig1: MRI Brain tumor Detection Steps

Image Acquisition

Acquirement is the first and foremost step in tumor detection process. It is the action of retrieving an image from a MRI Machine. The detection process cannot do any actual and formal processing without an MRI image. MRI is an especially technological elaboration in

the medical field that yields images with extra ordinary tenacity to sense and then can categorize illnesses that are invent in the organs of the sick person's body. One situation is possible to identify from reading an MRI image within 2.56×10^{11} Nano seconds. The following view explains the brain and its angles. The following figure shows the sample brain MRI from Real Patient Database.

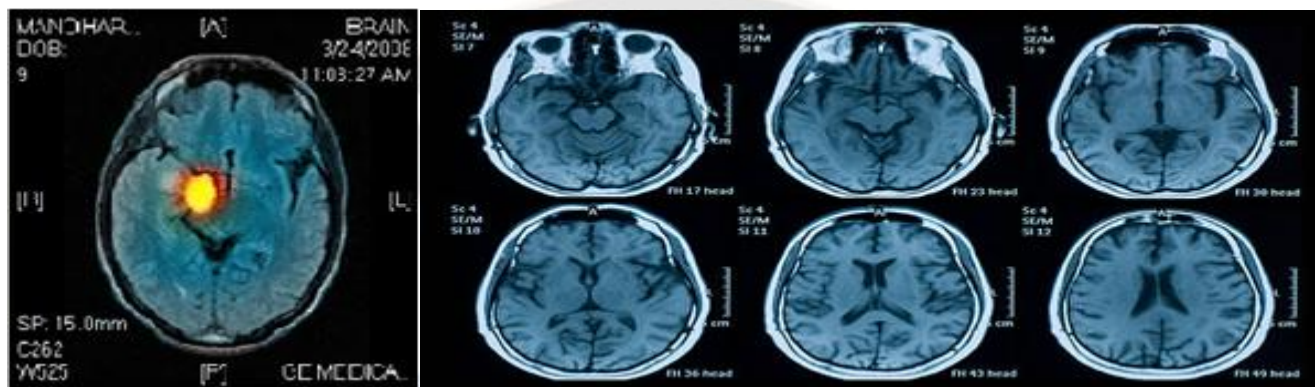


Fig 2: a) Single Brain MRI b) Brain View with different angle

The intention of Magnetic acquirement varies considerably from those for water or fat, protons in organic tissues. Thus, these differences play a critical role in the selection and optimization of pulse sequences for hyperpolarized-gas applications

Preprocessing and Enhancement

This review for pre-processing and enhancement through Magnetic Resonance Image (MRI) is ainline andirected image enhancement method and is based on the first derivative, resident data. Sonali Patil etal [2] explained media filter for preprocessing an image enhancement. In Preprocessing and Enhancement phase, medical Image is renewed into standard format with contrast manipulation, noise reduction by background removal, edge sharpening,

filtering process and removal of film artifacts. Preprocessing functions comprise those processes that are routinelyvitalformer to the core data study and removal of facts, and are largelyconvened as radiometric or regular corrections. The next one is enhancement method herethe advent and bases of image artifacts that can occur with MRI systems should be accepted and modified-raymarks, the high frequency components are removed finally unwanted skull portions on the MRI are removed. Selvanayaki etal[7] describes Median Filter can remove the noise, the high frequency components from MRI without disturbing the edges, bandwidth etc and it is used to reduce salt and pepper noise. Jyoti Panwar et al[3] performed image preprocessing using image gradient method.

TABLE 1: Review Paper Analysis

S.No	AuthorName	Paper Name	Year	Process	Method - Preprocessing
1	Abd El Kader Isselmoul , Guizhi Xu ,Shuai Zhang	Improved Methods for Brain Tumor Detection and Analysis Using MR Brain Images	2019	Segmentation	fuzzy c-means algorithm, improved feed forward neural network, self-organizing map

2	Sonali Patil,Dr.V.R.Udupi	Preprocessing To Be Considered For MR and CT Images Containing Tumors	2012	Preprocessing	Median Filter
3	Jyoti Panwar, Andrea S. Doria	Magnetic Resonance Imaging Data Acquisition	2021	Image Acquisition	Gradient artefact
4	Md Shahariar Alarm et.al	Automatic Human Brain Tumor Detection in MRI Image Using Template-Based K Means and Improved Fuzzy C Means Clustering Algorithm	2019	Segmentation	template-based K means, fuzzy C means
5	Priya Patil et.al	A Review Paper on Brain Tumor Segmentation and Detection	2017	Segmentation	F-Transform (Fuzzy Transform) 2) Morphological operation.
6	Saurabh Kumar, Iram Abid, Shubhi Garg, Anand Kumar Singh, Vivek Jain	Brain Tumor Detection Using Image Processing	2019	Segmentation	Wavelet Method,Support Vector Machine
7	Selvanayaki K,Dr.Karan M	Improved Implementation of Brain MR Image Segmentation using Meta heuristic algorithms'	2010	Segmentation	Block based ,Ant Colony Optimization
8	Selvanayaki,Dr.Karnan M	CAD System for Automatic Detection of Brain Tumor through Magnetic Resonance Image- A Review	2010	Segmentation	Review all Techniques for Brain MRI Segmentation
9	Vachan Vadmal, Grant Junno, Chaitra Badve, William Huang, Kristin A. Waite, and Jill S. Barnholtz-Sloan	MRI image analysis methods and applications: an Algorithmic perspective using brain tumors as an exemplar	2020	Segmentation	Low pass filter,fuzzy C means
10	Subhashis Banerjee, Student Member	Brain Tumor Detection and Classification from Multi-Channel MRIs using Deep Learning and Transfer Learning	2017	Classification	Deep Convolutional Neural Networks, ConvNets models
11	Swapnil R.Telrandhe, et.al	Brain Tumor Segmentation	2011	Segmentation	Edge detection Method

III.Segmentation

The Barrier of an image strains the division or parting of the image into provinces of associated attribute. The Ultimate goal in enormous quantity of image processing request is to extraction hermetic structures from the image data from which a elucidation, amplification, or imagined of the section can be provided by the machine. The Segmentation of brain tumor from magnetic resonance images is an vital but inefficient task performed by medical experts. The evaluation clarified numbers of

procedures are available in this brain tumor detection and segmentation. Expressly Fuzzy C Means-Means, Support vector Machine (SVM) approaches, Morphological Operations are used to segment tumor texture in the brain MRI.The accurate segmentation of MRI image into different tissue classes, especially gray matter (GM), white matter (WM) and Cerebrospinal fluid (CSF).In brief, segmentation regulates the Regions of Interest(ROIs) in an image. This does not mean that the segmentation will try to determine the type of the region,

but merely determine the pixels in an image which belong to the same item.

The digital image processing community has developed several segmentation methods, many of them ad hoc. Four of the most common methods are: 1) amplitude thresholding, 2) texture segmentation 3) template matching, and 4) region-growing segmentation. It is very important for detecting tumors, edema and necrotic tissues. These types of algorithms are used dividing the brain images into three categories (a) Pixel Based (b) Region or Texture Based (c) Structural Based. Several authors Suggested various algorithms for segmentation .The segmentation is the most important stage for analyzing image properly since it affects the accuracy of the subsequent steps. However, proper segmentation is difficult because of the great verities of the lesion shapes, sizes, and colors along with different skin types and textures. In addition, some lesions have irregular boundaries and in some cases there is smooth transition between the lesion and the skin. To address this problem, several algorithms have been proposed. They can be broadly classified as thresholding, edge-based or region-based, supervised and unsupervised classification techniques Threshold segmentation, Water shed segmentation, Gradient Vector Flow (GVF) ,K-mean Clustering ,Fuzzy C-means Clustering

Summary and Conclusion

In this survey paper numerous detection methods of brain tumor through MRI has been deliberate and linked for the period of recent era .This is charity to attention on the current developments of medical image processing in relation of brain tumor detection process. We have designated several approaches in brain image processing and to discussed rations and belongings of techniques in tumor detection .This paper is used to give more information about brain tumor detection and segmentation methods. It is a breakthrough for analyzing all technologies relevant to brain tumor from MRI in Medical image processing. In this paper, shows few steps about brain tumor detection process such as: The Preprocessing and Enhancement Technique Segmentation Algorithm and their performance have been studied and compared.

In this paper, we have proposed different techniques to detect and segment Brain tumor from MRI images. To extract and segment the tumor we used different techniques such as SOM Clustering, k-mean clustering, Fuzzy C-mean technique, curvelet

transform. It can be seen that detection of Brain tumor from MRI images is done by various methods, also in future work different automatic methods achieve more accuracy and more efficient.

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