A New Framework for Mri Brain Tumor Detection and Segmentation

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ABSTRACT: A brain tumor is an abnormal mass of cells growing within the brain. Tumors can be classified into two types: primary tumors, which originate from brain cells, and secondary tumors, which result from cancer cells spreading to the brain from other organs such as the lungs or breast. Magnetic Resonance Imaging (MRI) is widely used for brain tumor detection due to its high resolution and superior image quality. In this study, we propose a novel data mining framework for brain tumor detection using MRI scans. The proposed framework consists of seven key stages: Preprocessing, Enhancement, Segmentation, Feature Extraction, Feature Selection, Classification, and Performance Analysis. In the Preprocessing stage, unwanted artifacts and non-relevant portions of the MRI are removed. During Enhancement, noise in the images is reduced using various filtering techniques. The Segmentation stage focuses on isolating tumor regions from the brain MRI. Feature Extraction and Feature Selection are employed to identify and extract relevant tumor-related pixels. The Classification stage uses data mining and machine learning techniques to categorize or detect anomalies in the brain. Finally, Performance Analysis is conducted to evaluate the effectiveness of the proposed approach. This framework aims to improve the accuracy and efficiency of brain tumor detection through advanced data mining and image processing techniques.

Keywords: Brain Tumor, Magnetic Resonance Image, Preprocessing, Enhancement, malignant (cancerous).

1. INTRODUCTION:

Brain tumors have been increasingly reported in India, as shown by data from multiple cancer registries since 1982. According to the Global Cancer Observatory's 2022 report, brain tumors rank 14th among all types of cancer in the country and are expected to rise further in the coming years. A key factor contributing to this trend is the broader availability and use of imaging technologies such as MRI and CT scans, which has led to higher rates of diagnosis and reporting.

1.1 Brain Tumor

Brain tumors can affect individuals of all age groups, with the incidence being nearly equal among men and women. [The Hindu, June 04, 2025, 04:00 PM IST]. Yearly people affected rate is increasing. Research on brain tumors is ongoing because brain tumors are complicated, life-fatal, and not yet fully understood. Scientists and medical professionals are working to improve diagnosis, treatment, and outcomes for patients.

A 2025 National Institutes of Health (NIH) report estimated 322,000 new brain and central nervous system (CNS) tumors globally in 2022, with the highest incidence rates observed in Northern America and Western Europe. Brain and CNS cancer burdens are increasing globally, with a significant rise from 1990 to 2019 in the number of new cases, though the overall mortality rate remained relatively stable. Incidence rates generally increase with age, and men tend to have higher rates of brain cancer than women. These primary tumors can be benign is called non-cancerous and malignant is called cancerous. Benign tumors grow slowly and do not spread elsewhere or invade the surrounding tissues. However, they can put pressure on the brain and compromise its function. On the contrary, the malignant tumors grow rapidly and spread to surrounding tissues.

1.2 Magnetic Resonance Image (MRI)

The MR Imaging tomography is a method to produce detailed images of the internal structures of the body specifically for soft tissues like the brain, spinal cord, muscles and organs. MRI is used for brain imaging because it uses magnetic fields and radio waves (not ionizing radiation) to create detailed, high-resolution images of soft tissues like brain tissues. MRI brain scans offer high-contrast, multi-plane images with detailed views of soft tissues, making it possible to distinguish between structures such as white matter, gray matter, and cerebrospinal fluid. This differentiation is based on variations in proton density and the water or fat content of each tissue type. The following Fig 1 shows the sample MRI from 3T.

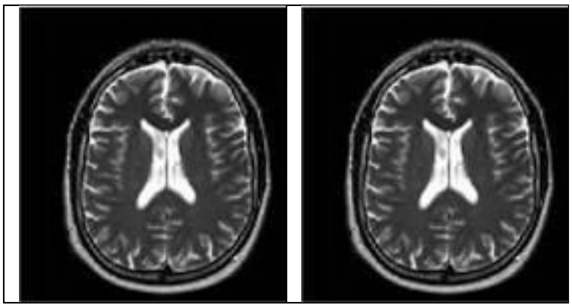

Fig 1: Sample MRI

2. LITERATURE SURVEY

Uma et al. explains the detection of the brain tumor multiple techniques are developed by different researchers, but every technique has advantages and disadvantages. Mostly the researchers used MRI images because it gives a high-quality image [4]. The related research is done on the same domain by Sushma et al. [5] using k-means clustering and bilateral filtering. They proposed the system for efficient detection of brain tumor. Another research is done by Raj and Shreeja [6]. They used multiple steps like K-means clustering and Hierarchical Centroid Shape Descriptor (HCSD), feature extraction and classification method. From feature extraction they extracted the multiple features of the tumor region by using the Gray Level Co-Occurrence Matrix (GLCM). KNN was used for the classification of the tumor based on the extracted features from the training and testing data.

Continuous increase in the number and size of databases, parallel data mining is a natural and cost-effective approach to tackle the problem of scalability in data mining. Recently there has been considerable research on parallel data mining [1]. the Max-Miner algorithm for mining maximum frequent itemset from large databases. MaxMiner applies several new techniques for reducing the space of itemset considered through superset- frequency based pruning [2]. Diagnosis of Brain Tumors from Magnetic Resonance Spectroscopy using Wavelets and Neural Networks aims to improve the speed and accuracy of diagnosis, providing decision support for radiologists [4]. Gupta Says that Mining knowledge and providing scientific decision-making for the diagnosis & treatment of disease from the clinical dataset is therefore increasingly becoming necessary. Aim of this study was to assess the applicability of knowledge discovery in brain tumor data warehouse, applying data mining techniques for investigation of clinical parameters that can be associated with occurrence of brain tumor. Surendran et al exolans [*]Convolutional neural network (CNN) techniques, preprocessing harmonization methods help to remove the scanner effects and improve the radiomics reproducibility in brain MRI radiomics. Asly et al explains MRI images of the brain are extremely useful in the medical field for diagnosing various diseases and injuries related to the brain. Magnetic resonance imaging (MRI) of the brain provides high-quality 2D or 3D images of the brain and cerebrum stem utilizing magnetic flux and radio signals. The following table shows the existing methods on brain MRI.

3. OVERVIEW OF BRAIN TUMOR DETECTION

The overall structure of brain tumor segmentation and detection involves seven key steps: First In Preprocessing, all brain MRI images undergo preprocessing to remove unwanted artifacts such as film labels, patient details, and directional markers. Second Enhancement, Image enhancement techniques are applied to improve image quality by filtering out noise from the MRI scans. Third Segmentation the enhanced images are segmented to differentiate between normal and abnormal (affected) pixels, which is crucial for analysis. In fourth step is Feature Extraction, Suspicious or abnormal pixels are identified, and relevant features are extracted using effective techniques. In fifth feature Selection, The extracted features are carefully analysed and selected for further processing. Classification: The selected features are used to classify the MRI images as either tumor or non-tumor. Fifth tumor Detection,The final stage confirms and highlights the presence and location of tumors based on the classification results.

Ostellino et al. Brain MRI images suffer the presence of noise artifacts, non-uniformities, and are affected by the intrinsic differences in the anatomy of human brains.The MRI brain images are two types one is T1 Weighted and T2 Weighted. T1 weighted only contains tissues and T2 weighted contains water and Fat.Repetion time (TR) is very short in T1 and very long in T2. In preprocessing, Filters are used to remove noises and flim artifacts on Brain MRI. Preprocessing harmonization methods help to remove the scanner effects and improve the radiomics reproducibility in brain MRI radiomics. Asly et al explains MRI images of the brain are extremely useful in the medical field for diagnosing various diseases and injuries related to the brain. Magnetic resonance imaging (MRI) of the brain provides high-quality 2D or 3D images of the brain and cerebrum stem utilizing magnetic flux and radio signals. The following

table shows the existing methods on brain MRI.
Preprocessing is a crucial initial step for MRI brain tumor detection because it cleans, enhances, and standardizes raw image data to improve the accuracy of subsequent analysis by clinicians and automated systems. MRI scans often contain noise, artifacts, and variations that can obscure a tumor, making reliable detection difficult without first refining the images.
The main problem with the images is the inhomogeneity, unsharp boundaries and irregular noise which affects the results. Inhomogeneity means presence of some irrelevant information that must be removed. Unsharp boundaries are the most common problem in the images, they give blurry effect on the images that is why the information is not clear. To overcome these problems, we use the bilateral filter with the other techniques for the effective detection and segmentation. The proposed framework presents the detection and classification of the brain tumor. Bilateral filter is used to remove noise and preserves details. Bilateral filter is the best to preserve edges, sharpens the boundaries and takes care about the details of the image. By doing segmentation and classification we get the tumor detected The following Fig 2 Shows the Original Patient MRI(Before Preprocessing).

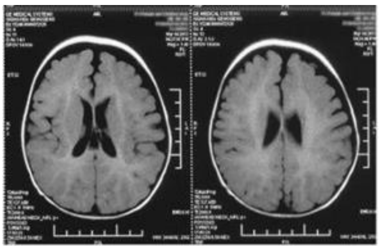

Fig 2 : Original MRI Scan Image

3.1 Enhancement

End of Preprocessing, the enhancement stage will produce Quality MRI images for further process. The MRI Brain image Contains film artificates and noises, This Enhancement is going to produce MRI brain images without noises, and it contains number of Sub Steps like Noise Reduction, Contrast Enhancement, Geometric Correction, Registration. In Noise reduction, MRI images can be affected by various noise sources, such as electrical interference and variations in the magnetic field. Noise reduction techniques can help reduce the amount of noise in the images, resulting in more precise and accurate images. Number of Enhancement techniques are there first one is Contrast enhancement: MRI images often have low contrast, making it difficult to distinguish between different tissues and structures. Contrast enhancement techniques can help to increase the contrast of the images, making it easier to see the details. Geometric correction: MRI images can sometimes be distorted due to the complex nature of the magnetic field used to generate them. Geometric correction techniques can help correct these distortions, making images more accurately aligned with the patient's anatomy.Registration: MRI images of different body parts or taken at different time pointscan be registered or aligned, enabling comparison and analysis.

3.2 Segmentation

MRI images often contain a large amount of data, and it can be helpful to separate different structures or tissues in the image for further analysis. Segmentation techniques can identify and extract specific structures or tissues from the images. Brain MRI segmentation plays a vital role in accurately distinguishing brain structures from tumors, edema, and other abnormalities, thereby supporting precise diagnosis, treatment planning, monitoring, and surgical guidance. It delivers detailed quantitative information for various neurological conditions and research by identifying specific anatomical regions—such as gray matter, white matter, and cerebrospinal fluid—or by delineating the exact boundaries and extent of a tumor. Kalifa et al. The aim of image segmentation is to divider a medical image into different regions and to extract the area of interest. In particular, it is used for separating components from the remainder of the image so that they can be observed or recognized as objects. The segmentation mostly based on three types edge based, Pixel Based and Region Bassed. Pixel-based Brain MRI Segmentation refers to the process of classifying each pixel in an MRI scan according to the tissue type or region it represents, such as gray matter, white matter, cerebrospinal fluid(CSF), or abnormal regions like tumors and edema.

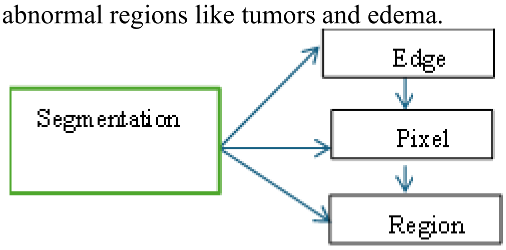

Fig 3 : Segmentation Methods

4. FEATURE EXTRACTION AND SELECTION:

The goal of feature selection is to eliminate irrelevant and redundant features from the input data, retaining only a subset of relevant features to build more robust classifiers. This process typically enhances both the training speed and the accuracy of the final classifier. Theoretically, achieving optimal feature selection for supervised learning would require an exhaustive search through all possible feature subsets. However, when dealing with a large number of features or complex models, such a complete search is computationally infeasible. Therefore, supervised learning algorithms are often used to identify an approximate but effective subset of features tailored to a specific classifier, rather than striving to find the absolute optimal set.

Conclusion

The consideration of tumors is a stimulating and extremely exact task, where certainty and accuracy are of paramount importance. Therefore, a distinct methodology that highlights inventive methods for enhancing image-based cancer segmentation and detection is highly desirable. This paper presents a half-done analysis of recent methods proposed for the analysis of MR brain images. The presentation of these algorithms has been evaluated based on accuracy, sensitivity, specificity, and their applicability in real-time scenarios. Since brain tumor detection is both complex and sensitive, precision and reliability play a crucial role in the efficiency of the chosen techniques.

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