Survey on Brain Tumor Identification

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Abstract

Brain tumors are caused by the growth of abnormal cells inside the Brain. Brain tumor can be classified as Benign (non cancerous) and malignant(cancerous). Malignant brain tumors usually grow rapidly when compared to benign tumors, and aggressively spread and affect the surrounding tissues. Detection of tumor in brain can turn out to be cumbersome, owing to the complex organization of the Brain. The cost of making an error in Identifying a Malignant Tumor from a Benign Tumor is too high. At a time, when cases of Brain Tumors are growing, mostly among people of age between 65 and 79, but not just confined to that age bracket, we can take advantage of the advancement in the field of technology and accurately identify tumors and help save lives.

*Keywords***:** *brain; tumor; identification; MRI*

1. Introduction

The brain is amongst the most important organs of our body. It is the most crucial part of our nervous system, and consists of nerve cells and supportive tissues like glial cells and meninges. The brain can be divided into three major parts, each part responsible for carrying out various tasks – they help control activities like that of breathing (performed by brain stem), activities like that of movement of muscles for walking (performed by cerebellum) and helps in controlling our senses like that of our memory, emotions, vision, thoughts and personality (cerebrum).
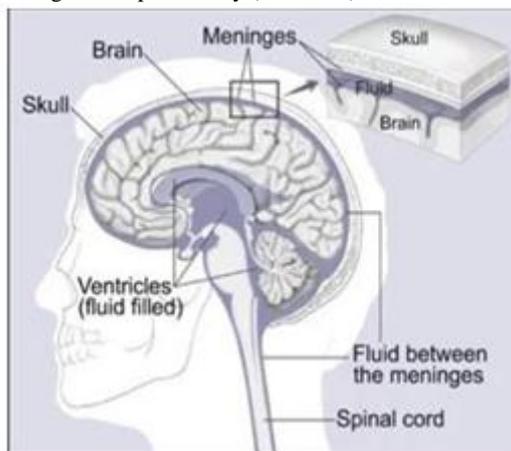

Fig. 1: Brain and nearby structures [16]

The brainstem comprises the medulla, the midbrain and the pons. It helps in controlling activities like that of breathing, heart rate, digestion and other autonomic processes. It also helps to connect the brain with the spinal cord and the rest of the body.

The cerebellum has a key role in activities like motor control, balance, as well as certain cognitive functions such as language, attention, emotional functions (like responses generated from fear and pleasure) and helps in processing of memories that are procedural in nature.

The cerebrum constitutes about 75% of the brain by volume and 85% of the brain by weight. A sheet of neural tissue which is known as cerebral cortex covers the cerebrum. Nearly 90% of all the brain's neurons are found in the cerebral cortex. Fig.1 and Fig. 2 shows the brain and various parts in it.
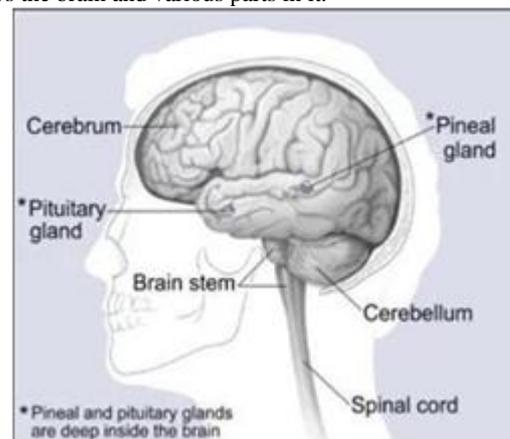

Fig. 2: Major parts of the brain [17]

Tumor refers to a new growth of abnormal tissue that is often uncontrolled and progressive. Brain tumors are caused by the growth of abnormally occurring cells inside the Brain. Brain tumor can be classified as Benign and malignant.

Brain tumors of benign nature are known to have distinct borders and are not deep-rooted in brain tissue. Thus it is easier to remove them surgically, given that the location where the tumor is located is safe to operate on. Even though benign tumors are less likely to reappear than malignant ones, there is a chance that even after a benign tumor is removed, it can come back. Benign Tumors can cause problems in some parts of the body, but they are generally not considered to be life threatening.

Malignant brain tumors are known to grow quicker when compared to the growth of benign tumors, and hostilely spread to the neighboring tissues. Even though brain cancer seldom spreads to other organs, it can spread to other parts of the brain as well as the central nervous system.

Once a Brain Tumor has been diagnosed, the first option is to remove it through surgery. However, for some tumors, surgery is not an option due to the criticality of the position of the tumor in the brain. In such circumstances, chemotherapy and radiation therapy can be used for destroying and reducing the tumor. At times as the last precautionary step, radiation or chemotherapy can be used post-surgery to destroy any left-over cancer cells. Deep seated tumors in the brain or tumors that are hard to reach can be treated with Gamma Knife therapy. Gamma Knife therapy involves the use of highly focused radiation.

2. Medical Imaging Techniques

Medical imaging has a decisive part to play in brain tumor diagnosis. Medical Imaging is a process of scanning to locate a tumor if present, and find out where exactly it is growing with the help of the computerized image generated in the process. Earlier, imaging methods like that of pneumoencephalography and cerebral angiography were used, which were invasive and often dangerous in nature. These have now been replaced by non-invasive and high-resolution techniques like that of Magnetic Resonance Imaging (MRI) and Computed Tomography(CT) scans.

Some Common Medical Imaging Tests Used Today:
Computerized Tomography (CT) Scan: Also known as the CAT scan (shown in Fig.3), it was developed in1972 by Engineer Godfrey N. Hounsfield (British) and physicist Alan Cormack (South African, later American). It uses a series of x-rays of the head taken from various directions. It provides means of viewing brain injuries quickly. A computer program implements calculations based on numerical integration, on the measured x-ray series to predict the amount of x-ray beam absorbed, within a small portion of the brain. Preferably, this data is obtained from the cross-sections of the brain.

Fig. 3: CT Scan Process[18]

Magnetic Resonance Imaging (MRI): uses radio waves and magnetic fields to create two- or three-dimensional images of parts of brain in high quality. It does not use radioactive tracers or X-rays in the process.
They make use of the body's natural magnetic properties, to produce detailed images from any part of the body. It can produce images of body parts which otherwise can't be visualized as well if done so using CT scans, ultrasound, or X-rays. Fig. 4 shows a sample of brain MRI while Fig. 5 shows an MRI machine.
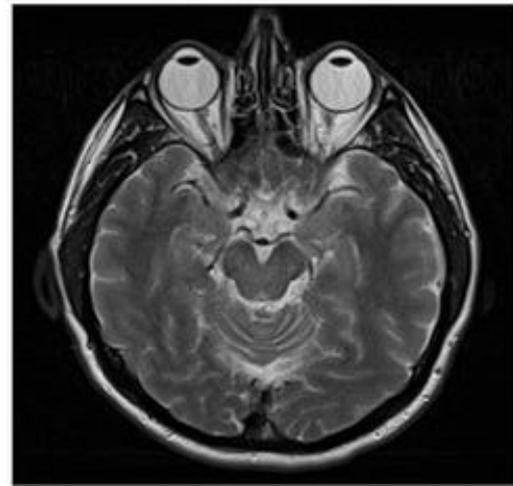

Fig. 4: Brain MRI sample [19]

Fig. 5: MRI Machine [20]

Functional magnetic resonance imaging (fMRI): Functional Magnetic Resonance Imaging is a technique used for imaging the activation of regions of the brain caused by various types of physical sensations (like smell, touch, sound, vision, taste) or activity involving logical/mental ability and/or motion. fMRI is non-invasive and safe, thus FMRI scans are being used more commonly as a tool for "brain mapping" in the fields of cognitive science.
Positron emission tomography (PET): It is a medical imaging technique that makes use of a special camera and a tracer. It helps measure physiological function by looking at blood flow, metabolism, neurotransmitters, and radio labeled drugs. During the test, the tracer liquid is put into a vein of our arm. The tracer flows through the bloodstream, and most of it is collected at the target tissue or organ, giving off particles that are tiny and positively charged(also known as positrons). An image is formed on the computer by recording the positrons, using the camera. Compared to MRI and CT scans, these images are not much detailed.
Magnetoencephalography (MEG): It is a safe process for examining activity of the human brain. Very Sensitive devices like Superconducting Quantum Interference Devices (SQUIDs) are used to find out the strength of the magnetic fields generated due to electrical activity in the brain. The measurement of on-going brain activity is allowed on a millisecond-by-millisecond basis. At the cellular level, a neuron present in the brain contains electrochemical properties. These properties make electrically charged ions flow through a cell. This slow ionic current flow leads to the generation of Electromagnetic fields.

Although the strength fields accompanying a single neuron is in significant, when hundreds of thousands of neurons get excited

together in a particular area, they generate a significant amount of magnetic field outside the head. Compared to the earth's magnetic field, the sensors or SQUID sensors, which can sense and amplify magnetic fields that are generated by neurons located some centimeters away from the sensors. Neuromagneticsignals emitted by the brain is really small. Thus, Magnetoencephalography (shown in Fig.6) scanners makes use of superconducting
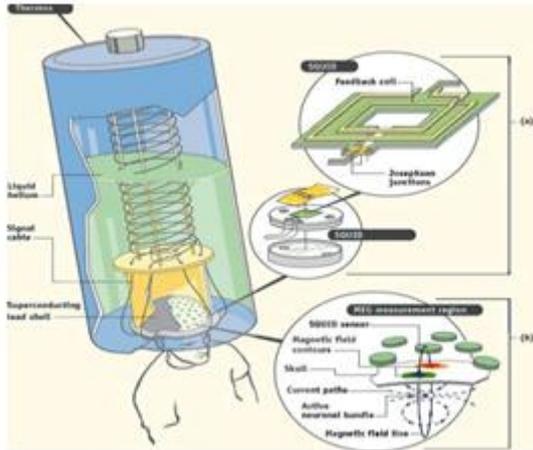

Fig. 6: Magnetoencephalography [21]

A. Magnetic Resonance Imaging (MRI):

Initially known as Nuclear Magnetic Resonance Imaging, Magnetic Resonance Imaging is a type of NMR, even though the word 'nuclear' in the abbreviation is no longer used. Certain atomic nuclei can absorb and emit radio frequency energy when they are placed in an external magnetic field. In MRI used in the medical field, protons or atoms of hydrogen are preferably used for creating an evident RF signal which is received by the antennas that work in area close to the subject which is being studied. Protons or atoms of Hydrogen are known to occur obviously in people and other biological organisms in plenty, specifically within fat and water. Thus, the location of fat and water in the body are mapped by most MRI scans. The nuclear spin energy transition is excited by the pulses of radio, and magnetic field gradients localize the signal in space. By varying the constraints of the sequence of the pulse, various contrasts can be generated between tissues based on the relaxation properties of the atoms of Hydrogen within.

Since its inception, the popularity of magnetic resonance imaging (MRI) scanners has grown manifolds. Using MRI scans Doctors help diagnose cancer, brain tumors, strokes, tendonitis, amongst others. An MRI scan is a highly versatile imaging technique and the most optimum way to look inside the human body without cutting it open. A variety of physical and chemical data, as well as detailed spatial images are produced by MRI scans. The constant rise in demand for performing MRI scans within the medical field has raised alarms about its cost effectiveness and over-diagnosis.

Mechanism**:** When the person to be scanned is positioned within a MRI scanner, it will form a strong magnetic field around the area that is to be imaged. Protons or atoms of hydrogen in tissues that have water molecules create a signal which is further dealt with before forming an image of the body. In the first step, energy from a magnetic field is smeared over the patient at optimal resonance frequency. The protons or atoms of hydrogen upon being excited emit a RF signal, which is further measured using a receiving coil. The rate at which the excited atoms return to their equilibrium state determines the contrast between the tissues.
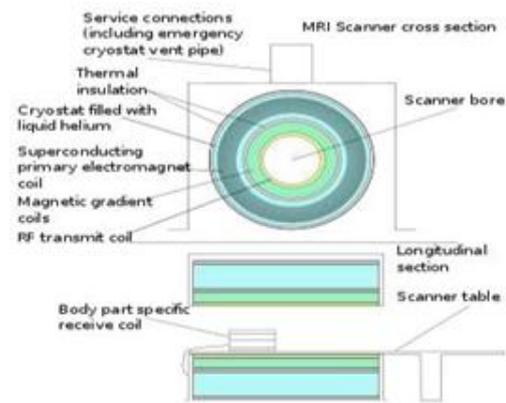

Fig. 7: MRI System [22]

The main parts of a MRI scanner includes the main magnet, that helps to polarize the sample, the gradient system which helps localize the Magnetic Resonance signal and the Radio Frequency system, which helps to excites the sample as well as detect the resulting NMR signal, and the shim coils which is used to correct shifts in the homogeneity of the main magnetic field. The entire system (shown in Fig.7) is controlled by computers.

MRI requires a strong and uniform magnetic field. While most of the systems run at 1.5T, there are systems that run on field strength ranging between 0.2 and 7T (Here, T refers to Tesla – Used to measure the field strength of the magnet) an are commercially available. Most clinical magnets are superconducting magnets, requiring helium in liquid form. Permanent magnets can be used to obtain lower field strengths, which are frequently used in "open" MRI scanners for patients suffering from Claustrophobia. In the recent past, MRI has also been carried out using ultra-low fields.

3. Literature Review of Methods Used for Identification of Brain Tumor

A. Fuzzy C-means Clustering (FCM)

A clustering algorithm organizes items into groups based on some criteria of similarity. Fuzzy c- means is a clustering method which allows a data item to belong to two or more clusters. The membership degree of each data item is provided by a probability distribution over the groups/clusters.

G.S.Sable & G. P. Anandgaonkar [1] uses median filtering for pre-processing the input image. Segmentation is done next using FCM where membership value of the fuzzy set

(defining the fuzziness of the image and information present in the image) ranges within 0 to 1. Here a matrix M is initialized first and center vectors are calculated. K steps are performed till termination value is reached. Threshold coding is done for feature extraction where the darker pixels are made darker and the white pixels made brighter. Then the tumor area is calculated and displayed.

Prof. A.S.Bhide et al. [2] uses median filter for noise removal and FCM for segmentation. The filtered image is converted to grey in pre-processing and FCM applied to it gives the segmented tumor. [2] uses diameter method for volume calculation of the tumor which was otherwise done manually from the MRI films with callipers.

Advantages of this method: Requires no prior information on the images to segment, less memory requirement, less execution time, less number of iterations needed in clustering.

Segmentation accuracy in FCM ranges from 32% to 89% of detected tumor pixels which can be further improved.

B. K Nearest Neighbor

KNN can be used for both classification and regression predictive problems. It belongs to the supervised learning domain. KNN algorithm is based on a distance function and voting function. Nikita V. Chavan et al. [3] uses Gaussian filter for filtering the MRI, GLCM (Gray Level Co- occurrence Matrix) based method for feature texture extraction and KNN classifier to classify the MRI images either as normal (no tumor/benign) or abnormal (malignant tumor).

This method is robust to noisy training set, effective on large training data, but has high computation cost & value of parameter K has to be determined.

A classification accuracy of 96.15% has been achieved here. Future work can focus on the use of supervised technique like SVM (Support Vector Machine) and unsupervised technique like SOM (Self Organization Map) to get more classification accuracy.

C. Watershed Algorithm

Benson C.C. et al. [4] proposes the use of marker based watershed algorithm for the segmentation of the tumor area. This improved version is used because watershed algorithm has few drawbacks, It faces the over segmentation problem due to noise and other unwanted effects in the image. An atlas based method is used in order to detect internal and external markers. Here different combinations of features are used for segmentation purpose. Each combination gives prominent results. This method gives better result than the others. Future work may include identification of markers automatically and segmenting the tumors automatically based on the markers.

Shweta Pandav [5] proposes the extraction of brain tumor from MRI using the gradient magnitude calculation and Marker Controlled Watershed Segmentation (MCWS). This technique gives efficient result, is easy to execute and can be managed easily. Future work may include the calculation of various attributes of the tumor region (volume, area etc.). This method can be extended to 3D color imaging. With large data sets the tumor can be classified as benign or malignant.

Yogita Sharma & Parminder Kaur [6] experiments with two methods- watershed segmentation and K means clustering. The MCWT is generally for problems where adjacent objects are present in an image and we need to separate them with image processing operations. K-means clustering is a method of vector quantization which is popular for cluster analysis. The methods proposed her can be used for the segmentation of low contrast images and medical images. Advantages include calculation of various parameters and reduced time consumption. Future work may include better GUI, and other techniques.

Sudipta Roy & Samir K. Bandyopadhyay [7] proposes the use of watershed segmentation with sobel edge detection technique and the area of the tumor is displayed. This is an interactive segmentation method which lets users to segment tumors in MRI of brain quickly and efficiently. Limitation of this technique can be found in case of pathologic tissue types which were not seen before, thus, could not be captured. Nevertheless, this method can automatically identify and segment various types of brain tumors with a proper quality. For further work, greater number of brain structures can be studied, explore higher dimensional data and improve UI, investigate possibility to resolve the present issues.

D. Decision Tree

Janki Naik& Prof. Sagar Patel [10] proposed the detection and classification of tumor in brain MRI using Decision Tree. Techniques proposed for pre-processing are Median filtering, morphological opening, and power law transformation. They used a GLCM for feature extraction, mining association rules in order to discover associations between items in a database and classification based on decision tree, naive Bayesian classification.

Decision tree classification resulted in accuracy of 96% where as Naive Bayesian classifier gave an accuracy of 88.2%. Sensitivity of 93% has been found in classification of brain tumor using decision tree classifier. This technique classifies the brain MRI as normal (no tumor or benign) or abnormal (malign) in an efficient way.

Zolt´an Kap´as et al. [11] presents preliminary results (detection and localization of tumors in MRI volumes) obtained using the random forest technique. Keeping three goals in mind, that is, Histogram normalization, feature computation and missing data, pre-processing has been carried out. In order to overcome overfitting due to the use of decision tree, they proposed the usage of random forest classifier where a set of trees that is trained with arbitrarily chosen data will make a particular decision based on a majority base. A post processing scheme is applied here which leads to relevant improvement of classification accuracy. This experiment shows that a random forest that is trained with samples from a particular volume cannot perform well in all cases. The solution of random forest in future will mostly contain groups of trees for better performance. In future work, this technique can be made to obtain better accuracy in segmentation using a complex random forest which is trained using data from many volumes.

Abhishek Bargaje et al. [9] proposes a method which does segmentation using a K-means, feature extraction using Discrete wavelet transform, feature reduction using principle component analysis, and classification using decision tree based adaptive boosting. This method can classify the given MRI image as normal or abnormal. In future, other functionalities like possible medication or stage of tumor can also be included.

E. Support Vector Machine

It is supervised classifier with associated learning algorithm. Chinnu A [12] used classification techniques based on SVM which were applied on brain image classification. Segmentation is performed using Histogram. Feature extraction of the MRI has been carried out by symmetrical, gray scale and texture features.

The proposed method results in the enhancement of accuracy rate and reduces the error rate of MRI brain tumor.

Pydi Venkatesh & Srinivasa Babji Josyula [13] proposed an automated method to classify Brain MRI into benign or malignant. The work here involves feature extraction and reduction followed by classification using SVM with various kernel functions. Techniques used here include skull masking, image enhancement for better feature extraction, GLCM, PCA, SVM. Future work may include the combination of LDA and PCA. Error rate can be decreased using hybrid SVM.

Bhavana Ghotekar & Mrs. K. J. Mahajan [14] proposed a method which undergoes image filtering using median filter, skull masking, feature extraction using GLCM, classification using SVM. This approach gives an accuracy of 83.33% and can be improved further.

F. Neural Networks

SUSHMA V. TELRANDHE et al. [15] proposed a method consisting image segmentation, training and testing of image by using back propagation neural network technique. The techniques used here include RGB to gray conversion, Adaptive Histogram Equalization, Morphological operation, Threshold of image, database training the image, identifying the tumor is present in brain or not. Thus, here two approaches are used for brain tumor detection, identification, classification. First method based on image processing and segmentation, and the second using neural network techniques.

Other Related Work:

Benson C.C. and Lajish V.L. [8] proposed a method which does MRI contrast enhancement and skull stripping using mathematical

morphology. For contrast enhancement low contrast MRI is taken as input and gives high contrast image is given as output, whereas, for skull stripping, contrast enhanced MRI is taken as input and skull striped image is given as output. This method can be used in various MRI applications such as tumor identification, volume analysis and classification.

Summary Table 1

Method	Advantages	Disadvantages
Fuzzy C-means Clustering (FCM)	Requires no prior information on the images to segment, less memory requirement, less execution time, less number of iterations needed in clustering.	Segmentation accuracy here, ranges from 32% to 89% of detected tumor pixels which can be further improved.
K Nearest Neighbor	Robust to noisy training set, effective on large training data.	High computation cost, value of parameter K has to be determined.
Watershed Algorithm	Reduced time consumption.	Can cause over segmentation.
Decision Tree	Deals with noisy or incomplete data, has the ability to select distinct features.	Results in high classification error rate if the training set is small, exponential increase in calculation as the problem grows.
Support Vector Machine (SVM)	Shows more accuracy when compared to other algorithms.	High algorithmic complexity and extensive memory requirements, limited by the choice of kernel used in SVM.
Neural Network	Ability to implicitly detect complex non linear relationships between dependant and independent variables	Usually hard to train and needs tuning of lots of parameters. Simpler and faster alternatives available that often provides better performance

Table I shows a summary of the various processes that have been used to identify brain tumor in MR images.

4. Conclusion

Diagnosing Tumor is a complex and cumbersome task. Recent works related to the task of identification (or classification of brain tumor – benign and malign) can be categorized into two. One is unsupervised classification, which includes fuzzy c-means and self-organizing map. The other category is supervised classification which includes K-Nearest Neighbor and Support Vector Machines (SVM). For the classification task at hand, the supervised algorithms perform better than the unsupervised algorithms with regards to accuracy. Most existing methods have accuracy below96%. Therefore in the future, research should be open to the scope for better accuracy.

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