Proceedings of the 2nd Virtual National Conference on Mathematical Modelling and Computation (NCMMC 2021)
10th & 11th December 2021

A Review of AI Techniques in Detecting Brain Tumors

Mathew Valan D L
Student
AI & ML
Coimbatore Institute of Technology

Kedareeshwar K S
Student
AI & ML
Coimbatore Institute of Technology

DineshKumar S
Student
AI & ML
Coimbatore Institute of Technology

SuriyaPrashanna J
Student
AI & ML
Coimbatore Institute of Technology

***Abstract* -- Artificial Intelligence is a very fast-growing field in the world now. The improvement of Artificial Intelligence (AI) and Machine Learning (ML) can help radiologists in the diagnosis of brain tumors without invasive measures. A brain tumor is an abnormal growth of cells in the brain. It can be cancerous or non-cancerous. Cancerous tumors are very dangerous and can even lead to death. So, detection of brain tumor at an early stage is very important. Before the advent of these AI technologies the process of detecting these tumors requires a lot of work and skill to perform these activities. The processes would include taking the samples from the brain manually which requires the most skill. Magnetic Resonance Imaging is a technique that gives a clear image of the human brain using electromagnetic radiations. Magnetic Resonance Imaging (MRI) is a very useful tool for diagnosing tumors in human brain. After the advent of MRI, the workload of the radiologists has become a bit easier. Here in this paper, we will be seeing about analysing the brain MRI images to detect the presence of tumors and to differentiate among them. After the advent of AI techniques, it provides a lot of methods to detect these tumors. This makes the workload of the consultor very easier. In fact, the AI models that we build will do the work of a radiologist and a consultor together. This paper will present the techniques involved in the implementation of various AI and ML techniques for the detection and classification of brain tumors using brain MRI images.**

Keywords - Artificial Intelligence, Machine Learning, Brain tumor, MR Imaging, Classification.

I.INTRODUCTION

A brain tumor is a tumor that develops in the cells of the brain. A growth, collection or mass of abnormal cells in the brain is called a brain tumor. The skull which encloses the brain is very rigid and any growth inside such a restricted space can cause problems [4].

It can be either noncancerous (benign) or cancerous (malignant) and vary greatly based on its location. The location of the tumor determines the effect on the central nervous system (CNS) along with its symptoms and growth rate. When benign or malignant tumors grow, they can cause the pressure inside your skull to increase, this can lead to brain damage and can be life-threatening also. Brain tumor treatment options depend on the type of brain tumor one has along with its size and location. Imaging tests can help doctors find out if the tumor is a primary brain tumor or if it is cancer that has spread to the brain from elsewhere in the body. Group pixels identical in colour and other low-level properties are known as super pixels. The super pixel's function is very useful in feature extracting that uses the simple linear iterative clustering (SLIC) algorithm [6]. It groups pixels into region based on similar values. These regions are used in image processing e.g., segmentation, can reduce complexity. Due to the reduction in image complexity from hundreds of thousands of pixels to only a few hundred super pixels, super pixels are computationally efficient. Imaging tests show pictures of the inside of the body. It is essential to promote early diagnosis of brain tumors because they are the most common cause of cancer-related deaths in children and people up to 40 years of age. Therefore, it is necessary to devise strategies to accelerate early diagnosis of brain tumors. An early diagnosis of brain tumor implies faster response in treatment, thereby increasing the surviving rates of patients. It has been difficult for doctors to diagnose the brain tumors, new research finds that causal machine learning models are not only more accurate than previous AI-based symptom checkers for patient diagnosis but, in many cases, can now exceed the diagnosis accuracy of human doctors. In general, diagnosing a brain tumor usually begins with magnetic resonance imaging (MRI). Magnetic resonance imaging

(MRI) is a medical imaging technique that uses a magnetic field and computer-generated radio waves to create detailed images of the organs and tissues in your body. Once MRI shows that there is a tumor in the brain, the most common way to determine the type of brain tumor is to look at the results from a sample of tissue after a biopsy or surgery.

According to the World Health Organization and American Brain Tumor Association, the most common grading system uses a scale from grade I to grade IV to classify benign and malignant tumor types. On that scale, benign tumors fall under grade I and II glioma and malignant tumors fall under grade III and IV glioma. The grade I and II glioma are also called low-grade tumor type and possess a slow growth, whereas grade III and IV are called high-grade tumor types and possess a rapid growth of tumors. If the low-grade brain tumor is left untreated, it is likely to develop into a high-grade brain tumor that is a malignant brain tumor. Patients with grade II gliomas require serial monitoring and observations by magnetic resonance imaging (MRI) or computed tomography (CT) scan every 6 to 12 months. Brain tumor might influence any individual at any age, and its impact on the body may not be the same for every individual.

The benign tumors of low-grade I and II glioma are considered to be curative under complete surgical excursion, whereas malignant brain tumors of grade III and IV category can be treated by radiotherapy, chemotherapy, or a combination thereof. The term malignant glioma encompasses both grade III and IV gliomas, which is also referred to as anaplastic astrocytomas.

Introduction of artificial intelligence into the healthcare has revolutionized the industry. In terms of magnetic resonance imaging (MRI), it has produced faster and better tumor and cancer detection with segmentation and localization. The machine learning is more adept than human medical practitioners due to the limitless storage, immediate historical recall, access to data, and speed of computation. In the study, however, counterfactual machine learning algorithms succeeded because they were more 'imaginative' than doctors [11]. This allows the AI to tease apart the potential causes of a patient's illness and score more highly than over 70% of the doctors, "said Babylon Health scientist and lead author of the study Dr. Jonathan Richens.

Automated defect detection in medical imaging using machine learning has become the emergent field in several medical diagnostic applications. Its application in the detection of brain tumor in MRI is very crucial as it provides information about abnormal tissues which is necessary for planning treatment. Studies in the recent literature have also reported that automatic computerized detection and diagnosis of the disease, based on medical image analysis, could be a good alternative as it would save radiologist time and also obtain a tested accuracy. Furthermore, if computer algorithms can provide robust and quantitative measurements of tumor depiction, these automated measurements will greatly aid in the clinical management of brain tumors by freeing physicians from the burden of the manual depiction of tumors.

This paper is organized as follows. Section I deals with the introduction; Section II gives the literature review followed by Section III with the methodologies. Section IV describes about the comparative analysis. Finally, section V gives the conclusion.

II.LITERATURE REVIEW

Chithra and Dheepa (2018), **Rai and Chatterjee (2020)**, the authors proposed a cascaded CNN architecture for the detection of tumors by extracting tumoral characteristics and recognizing tumor images automatically from mind MR images. However, the above scheme was needed more kernel to convolve feature map and SoftMax for pixel-wise classification. In addition, this scheme only detected the tumor exists or not using without segment the tumor area MR image [9][10].

Sandhya et al (2017), the authors proposed SVM for tumor identification. The adaptive threshold algorithm was applied for segmentation and features were extracted by using First Fourier Transform (FFT) [6].

Shree and Kumar (2018), introduced a probabilistic neural network classifier noise removal techniques, i.e., GLCM, DWT and segmentation to reduce the complexity which improves the accuracy. Due to, it clears the artifacts using the morphological filtering. The identification accuracy of brain tumor location by the probabilistic neural network classifier where both train and test dataset were used [7].

Soltaninejad et al. (2017a), the researchers proposed super pixel-based method for automated brain tumor identification and segmentation from Fluid-Attenuated Inversion Recovery Magnetic Resonance Imaging (FLAIR-MRI). The experimental results show that the proposed scheme improves the detection and segmentation performance by using Extremely randomized trees (ERT) classifier [5].

Soltaninejad et al. (2018), the authors introduced a 3D super voxel-based segmentation method for tumor segmentation in multi-modal MRI brain images. They are extracted several feature sets for each super voxel, including first order intensity statistical features, histograms of texton descriptor to classify each super voxel into the following three classes tumor core, oedema or healthy brain tissue by using random forest (RF) classifier. The method was evaluated based on two datasets such as (i) local clinical dataset: 11 images of patients and (ii) BRATS 2013 clinical dataset: 30 multimodal images [4].

Zhang et al. (2021), the authors proposed a Multi-Encoder Network (ME-Net) architecture with a new loss function named "Categorical Dice" for segmenting the 3D MRI image that reduces the feature extraction difficulty. They also used different weights for different segmented regions of the 3D MRI image to resolving the voxel imbalance issue. However, the segmentation results of this model are not sufficient for the enhancing tumor area of the tumor and multi-class segmentation problem [3].

Kumar and Vijayakumar introduced brain tumor segmentation and classification based on principal component analysis (PCA) and radial basis function (RBF) kernel based SVM and claims similarity index of 96.20%, overlap fraction of 95%, and an extra fraction of 0.025%. The classification accuracy to identify tumor type of this method is 94% with total errors detected of 7.5%.

Sharma et al. have presented a highly efficient technique which claims accuracy of 100% in the classification of brain tumor from MR images. This method is utilizing texture-primitive features with artificial neural network (ANN) as segmentation and classifier tool [2].

Cui et al. applied a localized fuzzy clustering with spatial information to form an objective of medical image segmentation and bias field estimation for brain MR images. In this method, authors use Jaccard similarity index as a International Journal of Biomedical Imaging 3 measurement of the segmentation accuracy and claim 83% to 95% accuracy to segment white matter, gray matter, and cerebrospinal fluid [1].

III. METHODOLOGY

In various research papers, the detection of brain tumor is done by applying Machine Learning and Deep Learning algorithms. When these algorithms are applied on the MRI images the prediction of brain tumor is done very fast and a higher accuracy helps in providing the treatment to the patients. This prediction also helps the radiologist in making quick decisions. In the proposed work, a self-defined Artificial Neural Network (ANN) and Convolution Neural Network (CNN) is applied in detecting the presence of brain tumor and their performance is analysed.

COMPARATIVE ANALYSIS

Year	Author	Method used	Accuracy
2014	Sharma et al	Artificial Neural Network (ANN)	100%
2018	Zahra Sobhanin et al	Deep learning techniques	73 – 79%
2019	Cui et al	Localized Fuzzy Clustering	83 – 95%
2019	Tonmoy Hossain et al	CNN	97.70%
2019	S. Somasundaram et al	SVM, ANN	91.6%, 94.82%
2020	Deepali Vikram Gorel et al	DNN	88.66%
2020	Zheshu Jia et al	SVM	98.51%

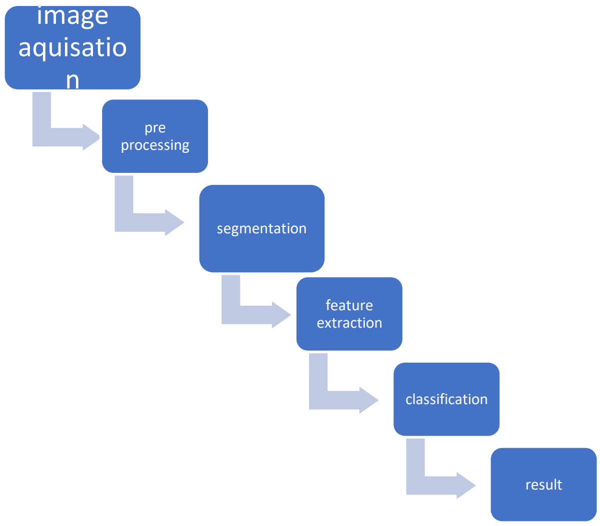


Image acquisition:

The proposed method has been implemented on real data for human MR Images dataset, some of them were obtained from the hospitals and the other were obtained from the internet.

A collection of MR images with brain tumors(fig-1) and without brain tumors(fig-2) are given below:

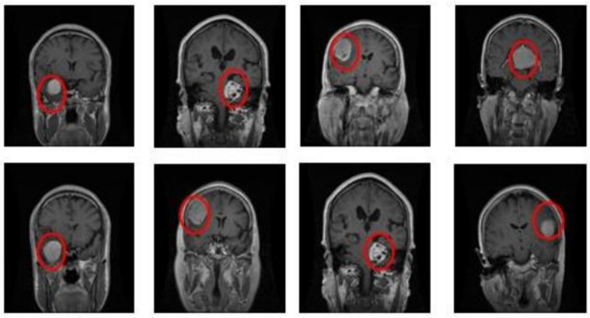


Fig 1: A collection of MR images with brain tumor.

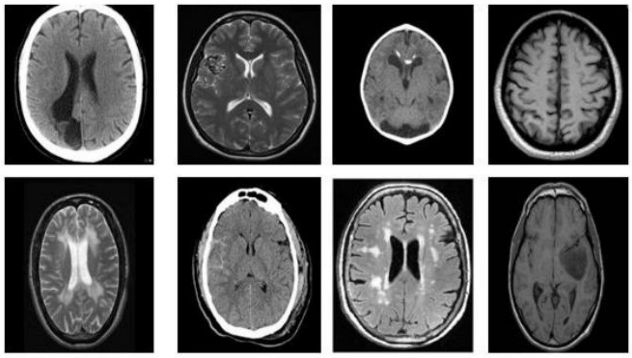


Fig 2: A collection of MR images without brain tumor

Image Pre-processing

The aim of pre-processing is to improve the quality of the image so that we can analyse it in a better way. By pre-processing we can suppress undesired distortions and enhance some features which are necessary for the particular application we are working for. Those features might vary for different applications.

For example, if we are working on a project which can automate Vehicle Identification, then our main focus lies on the vehicle, its colour, the registration plate, etc., We do not focus on the road or the sky or something which isn't necessary for this particular application. Similarly, in this case we focus on the tumors which is located in the acquired datasets.

Image segmentation - Image Segmentation is the process by which a digital image is partitioned into various subgroups (of pixels) called Image Objects, which can reduce the complexity of the image, and thus analysing the image becomes simpler.

Median filter for noise removal - Median filter is a non-linear filtering technique used for noise removal. Median filtering is used to remove salt and pepper noise from the converted grayscale image. It replaces the value of the centre pixel with the median of the intensity values in the neighbourhood of that pixel.

Image detection

When contrast is poor the contrast enhancement method plays an important role. In this case the gray level of each pixel is scaled to improve the contrast. Contrast enhancements improve the visualization of the MRI images. contrast enhancement technique is used for enhance the MRI image.

Edge detection

Edge detection is an image processing technique for finding the boundaries of objects within images. It works by detecting discontinuities in brightness. Edge detection is used for image segmentation and data extraction in areas such as image processing, computer vision, and machine vision.

Threshold

Image threshold is a simple, effective, way of partitioning an image into a foreground and background. This image analysis technique is a type of image segmentation that isolates objects by converting gray scale images into binary images.

Histogram

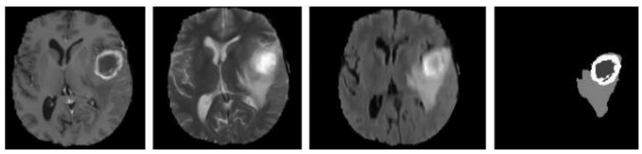
The histogram of an image mostly represents the comparative frequency of the various gray levels in the image. histogram techniques apply on input MRI image.

Morphological operation

Morphological operation used as an image processing tools for sharpening the regions. [2] Morphological image processing is a collection of non-linear operations related to the shape or morphology of features in an image.

Segmentation

Image segmentation is the process of partitioning a digital image into multiple segments. Image Segmentation is typically used to locate objects and boundaries in image, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics.



From above image,

Brain tumor segmentation. From left: T1-Gd, T2, FLAIR and Segmented Tumor. In segmented image; bright signal is active region; dark signal is necrotic core and medium level signal is edema. Images are generated by using BRATS 2013 data.

Feature extraction

Feature extraction is a process of dimensionality reduction by which an initial set of raw data is reduced to more manageable groups for processing. A characteristic of these large data sets is a large number of variables that require a lot of computing resources to process. Feature extraction is the name for methods that select and /or combine variables into features, effectively reducing the amount of data that

DIFFERENT IMAGE CLASSIFICATION TECHNIQUES ARE TABULATED BELOW:

Classification techniques	*Benefits*	*Assumptions and/or limitations*
Neural network	• Can be used for classification or regression • Able to represent Boolean functions (AND, OR, NOT) • Tolerant of noisy inputs • Instances can be classified by more than one output	• Difficult to understand the structure of an algorithm • Too many attributes can result in overfitting • Optimal network structure can only be determined by experimentation
Support vector machine	• Models nonlinear class boundaries • Overfitting is unlikely to occur • Computational complexity reduced to a quadratic optimization problem • Easy to control the complexity of decision rule and frequency of error	• Training is slow compared to Bayes and decision trees • Difficult to determine optimal parameters when training data is not linearly separable • Difficult to understand the structure of an algorithm
Fuzzy logic	• Different stochastic relationships can be identified to describe properties	• Prior knowledge is very important to get good results • Precise solutions are not obtained if the direction of decision is not clear
Genetic algorithm	• Can be used in feature classification and feature selection • Primarily used in optimization • Always finds a "good" solution (not always the best solution) • Can handle large, complex, nondifferentiable and multimodal spaces • Efficient search method for a complex problem space • Good at refining irrelevant and noisy features selected for classification	• Computation or development of the scoring function is nontrivial • Not the most efficient method to find some optima, rather than global • Complications involved in the representation of training/output data

Table 2: Comparison on classification techniques.

must be processed, while still accurately and completely describing the original data set.

Applications of Feature Extraction

Bag of Words

Bag-of-Words is the most used technique for natural language processing. In this process they extract the words or the features from a sentence, document, website, etc. and then they classify them into the frequency of use. So, in this whole process feature extraction is one of the most important parts.

Image Processing

Image processing is one of the best and most interesting domains. In this domain basically you will start playing with your images in order to understand them. So here we use many techniques which includes feature extraction as well and algorithms to detect features such as shaped, edges, or motion in a digital image or video to process them.

Auto-encoders

The main purpose of the auto-encoders is efficient data coding which is unsupervised in nature. this process comes under unsupervised learning. So, Feature extraction procedure is applicable here to identify the key features from the data to code by learning from the coding of the original data set to derive new ones.

Classification

Image classification is the process of categorizing and labeling groups of pixels or vectors within an image based on specific rules. The categorization law can be devised using one or more spectral or textural characteristics. Two general methods of classification are 'supervised' and 'unsupervised'.

Unsupervised classification

Unsupervised classification method is a fully automated process without the use of training data. Using a suitable algorithm, the specified characteristics of an image is detected systematically during the image processing stage. The classification methods used in here are 'image clustering' or 'pattern recognition'. Two frequent algorithms used are called 'ISODATA' and 'K-mean'.

Supervised classification

Supervised classification method is the process of visually selecting samples (training data) within the image and assigning them to pre-selected categories (i.e., roads, buildings, water body, vegetation, etc.) in order to create statistical measures to be applied to the entire image. 'Maximum likelihood' and 'Minimum distance' are two common methods to categorize the entire image using the training data. For example, 'maximum likelihood' classification uses the statistical characteristics of the data where the mean and standard deviation values of each spectral and textural indices of the image are computed first. Then, considering a normal distribution for the pixels in each class and using some classical statistics and probabilistic relationships, the likelihood of each pixel to belong to individual classes is computed. Finally, the pixels are labelled to a class of features that show the highest likelihood.

IV. CONCLUSION

In this survey of detecting brain tumor through artificial intelligence and machine learning by the usage of algorithms and assumption for execution of the problem in medical image processing and paved the way for efficient diagnosis, recognition and prediction in numerous domains of healthcare, brain tumor detection and classification being one of them. In future, one of the most important improvements that can be made is adjusting the architecture so that it can be used during brain surgery, for classifying and accurately locating the tumor. Detecting the tumors in the operating theatre can be performed in real-time conditions; thus, in that case, the improvement would also involve adapting the network architecture to a 3D system. By keeping the network architecture simple, detection in real time can be made possible.

REFERENCES

[1] **Cui et al**, Identifying the Best Machine Learning Algorithms for Brain Tumor Segmentation, Progression Assessment, and Overall Survival Prediction in the BRATS Challenge, April 2019.

[2] **Sharma et al,** Brain Tumor Detection based on Machine Learning Algorithms, May 2014.

[3] Zhang et al (2021) , Cross-modality deep feature learning for brain tumor segmentation, February 2021.

[4] Soltaninejad et al (2018) , MRI Brain Tumor Segmentation and Patient Survival Prediction Using Random Forests and Fully Convolutional Networks, February 2018.

[5] **Soltaninejad et al. (2017a) ,** Detection of Brain Tumor based on Features Fusion and Machine Learning, November 2018.

[6] **Sandhya et al (2017) ,** An Efficient MRI Brain Tumor Segmentation by the Fusion of Active Contour Model and Self-Organizing-Map, February 2019.

[7] **Shree and Kumar (2018) ,** Identification and classification of brain tumor MRI images with feature extraction using DWT and probabilistic neural network, January 2018.

[8] **Chithra and Dheepa ,** Di-phase midway convolution and deconvolution network for brain tumor segmentation in MRI images, February 2020.

[9] Rani and Chatterjee, A Novel Deep CNN Model for Classification of Brain Tumor from MR Images.

[10] V Ramya Manaswi and B Sankarababu, A Flexible Accession for Brain Tumor Detection and Classification using AI Methodologies, 2021.

[11] Bahadure et al, Image Analysis for MRI Based Brain Tumor Detection and Feature Extraction Using Biologically Inspired BWT and SVM, January 2017.

[12] Mehrotra, A Transfer Learning approach for AI-based classification of brain tumors, October 2020.

[13] Ghosh et al, A Comparative Study of Enhanced Machine Learning Algorithms for Brain Tumor Detection and Classification, October 2021.