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A Study on Brain Tumor Detection Algorithms for MRI Images

Rachana Ramachandran. R.P[1], N.Mohanapriya[2], Dr.L.Malathi[3]

[1]*P.G Scholar, Dept. of Computer Science Engineering, Vivekanandha College of Engineering for Women, Tamilnadu, India*
[2]*Assistant Professor, Dept. of Computer Science Engineering, Vivekanandha College of Engineering for Women, Tamilnadu, India*
[3]*Associate Professor, Dept. of Computer Science Engineering, Vivekanandha College of Engineering for Women, Tamilnadu, India*

Abstract - *Medical image processing is the one of the most demanding and promising field nowadays. Tumor is a rapid uncontrolled growth of cell. The tumor can be classified as benign, malignant and pre-malignant. When a tumor is noticed as malignant then the tumor leads to cancer. Earlier stage of tumor is used to be detected manually through observation of image by doctors and it takes more time and sometimes gets inaccurate results. Today different computer added tool is used in medical field. These tools provide a quick and accurate result. Magnetic Resonance Images (MRI) is the most widely used imaging technique for analyzing internal structure of human body. The MRI is used even in diagnosis of most severe disease of medical science like brain tumors. The brain tumor detection process consist of image processing techniques involves four stages. Image pre-processing, image segmentation, feature extraction, and finally classification. There are several existing of techniques are available for brain tumor segmentation and classification to detect the brain tumor. This paper presents a study of existing techniques for brain tumor detection and their advantages and limitations. To overcome these limitations, propose a spearman based brain tumor segmentation and Convolution Neural Network (CNN) based classifier. CNN based classifier used to compare the trained and test data, from this get the best result.*

Key Words: **MRI, CNN, Spearman algorithm, Segmentation, Classification, Deep Learning**

1. INTRODUCTION

Image processing is a process of analyzing, manipulating an image in order to perform some operation to extract the information from it. Medical imaging seeks to disclose internal structures hidden by skin and bones and also to diagnose and treat disease. And also it establishes a database of normal anatomy and physiology to make it possible to identify abnormalities. In today's world, one of the reasons in the rise of mortality among the people is brain tumor. Abnormal or uncontrolled growth of cell developed inside the human body is called brain tumor. This group of tumor grows within the skull, due to which normal brain activity is disturbed. Brain tumor is a serious life frightening disease. So which not detected in earlier stage, can take away person's life. Brain tumors can be mainly three varieties called benign, malignant, pre-malignant. The malignant tumor leads to cancer.

Treatment of brain tumor depends on many factors such as proper diagnosis and the different factor like the type of tumor, location, size, and state of development. Previously stage of tumor is used to be detected manually with the help of observation of image by doctors and sometimes it takes more time and results may be inaccurate. There are many types of brain tumor and only expert doctor can able to give the accurate result. Today many computers added tool is used in a medical field. These tools have a property of quick and accurate result.

MRI is the most commonly used imaging technique for inspecting internal structure of human body. Proper detection of tumor is the solution for the proper treatment. Also require accurate diagnosis tool for proper treatment. Detection involves finding the presence of tumor. Detecting brain tumor using image processing techniques involves four stages. Image pre-processing, segmentation, feature extraction, and classification. The primary task of pre-processing is to improve the quality of the Magnetic Resonance (MR) images, removing the irrelevant noise and undesired parts in the background and preserving its edges. In segmentation the pre-processed brain MR images is converted into binary images. Feature extraction is the process of collecting higher level information of an image such as color, shape, texture and contrast. And the classification process, the classifier is used to classify the normal trained image samples and the input image sample.

2. RELATED WORKS

Detection of brain tumor from the magnetic MR images or from other medical imaging modalities is a important process for deciding right therapy at the right time. MRI provides high qualities of images and visualizes structure of the body internally. Different types of tissues in the body can be renowned completely with MRI also contains fine information for treatment. Texture of MRI contains information of size, shape, colour, and brightness that texture properties helps to detect texture extraction. Different types of techniques have been proposed for classification of brain tumors for MR images particularly, fuzzy clustering means (FCM), support vector machine (SVM), artificial neural network (ANN), knowledge-based techniques, and expectation-maximization (EM) algorithm technique which are some of the popular techniques used for a region based segmentation and to extract the important

information from the medical imaging Techniques. Neural Network (NN) consists of an interconnected component; it contains the mimic properties of biological neurons. An overview and findings of some of the recent and outstanding researches are presented here.

Nilesh Bhaskarrao Bahadure, Arun Kumar Ray, and Har Pal Thethi [1] presented MRI based brain tumor detection and feature extraction techniques. To improve the performance and reduce the complexity involves in the medical image segmentation process, they introduced Berkeley wavelet transformation (BWT) based brain tumor segmentation. SVM based classifier is used to improve the accuracy and quality rate. The experimental results of proposed technique have been evaluated and validated for performance and quality analysis on magnetic resonance brain images, based on accuracy, sensitivity and specificity.

Andras Jakab, Stefan Bauer, et al. [2] introduced a multi modal brain tumor image segmentation (BRATS) technique. They found that different algorithms worked best for different sub-regions, but that no single algorithm ranked in the top for all sub-regions simultaneously. Also they try to fuse several good algorithms using a hierarchical majority vote yielded segmentations that consistently ranked above all individual algorithms, indicating remaining opportunities for further methodological improvements. The BRATS image data and manual annotations are used as publicly and it is available only through an online evaluation system. The first step of the proposed approach they evaluate the variability between the segmentations to quantify the difficulty of the different segmentation tasks. At last they perform an experiment that applies the hierarchical fusion algorithm to the automatic segmentations.

Israel D. Gebru, Xavier Alameda-Pineda, Florence Forbes and Radu [3] presented a weighted-data Gaussian mixture model. This model propose a new mixture model that associates a weight with each observed point and introduce the weighted-data Gaussian mixture and derive two EM algorithms. In this proposed method they derived a maximum-likelihood formulation and devised two EM algorithms, one that uses fixed weights (FWDEM) and another one with weights modeled as random variables (WD-EM). The first algorithm appears to be a straightforward generalization of standard EM for Gaussian mixtures; the second one has a more complex structure. The proposed WD-EM admits closed-form solutions and the algorithm is extremely efficient. They also demonstrate the effectiveness and robustness of the proposed clustering technique in the presence of heterogeneous data, namely audio-visual scene analysis.

Prateek Katiyar, Mathew R. Divine, et al. [4] explored an unsupervised segmentation approach tumor tissue populations for multipametric MRI. This proposed approach they aimed to accurately guess the intra-tumoral heterogeneity using a technique called spatially regularized spectral clustering (SRSC) on multiparametric MRI data. Also compare the efficacy of SRSC with the previously reported segmentation techniques in MRI studies. In these methods overestimated peri-necrotic and underestimated viable fractions, SRSC accurately predicted the fractional population of all three tumor tissue types and exhibited strong correlations with the histology. The accurate identification of necrotic, peri-necrotic and viable areas using SRSC may really assist in cancer treatment planning and add a new dimension to MRI-guided tumor biopsy procedures. The efficiency of SRSC on multi-parametric MRI data and delivered an accurate segmentation.

Zeynettin Akkus, et al. [5] implemented a deep learning technique for brain MRI segmentation. This technique they aim to provide an overview of current deep learning-based segmentation approaches for quantitative brain MRI. The performance of the deep learning methods depends highly on several key steps such as pre-processing, initialization, and post processing. The deep learning models that are highly robust to variations in brain MRI or have unsupervised learning capability with less requirement on ground truth labels are needed.

Anupurba Nandi [6] introduced a brain tumor detection using segmentation and morphological operators. This work uses K-Means clustering where the detected tumor shows some abnormality which is then rectified by the use of operators. Also basic image processing techniques to meet the goal of separating the tumor cells from the normal cells. The goal is obtained by applying thresholding, watershed segmentation and morphological operators. The factor used in thresholding is difficult to determine because the factor used for one image may not work for image. But this factor may be different for different images.

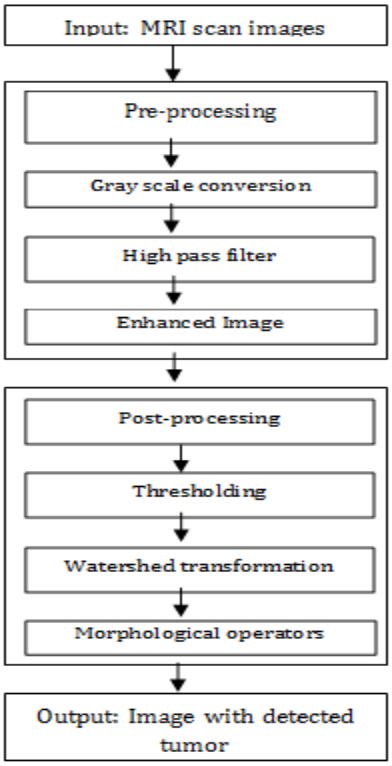

Fig -1: Basic Image Processing Techniques

R. Telrandhe, Amit Pimpalkar and Ankita Kendhe [7] proposed brain tumor detection for MRI images using segmentation and SVM. The SVM is used in unsupervised manner which will use to create and maintain the pattern for future use. Also to make this system an adaptive using SVM. Find out the texture feature and color features of MRI images. The proposed a system that can be used for segmentation of brain MR Images for Detection and identification of brain tumor. Find area of tumor and its type of tumor. The experimental results of the proposed system will give better result in comparison to other existing systems. This proposed system using K-Means segmentation with pre-processing of image. After the segmentation process the resulted image is shown in figure3.

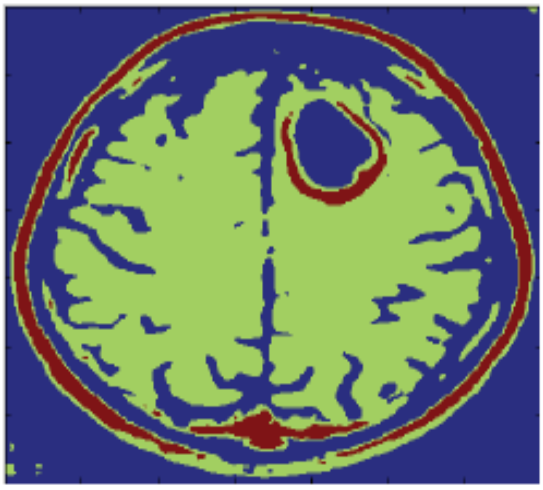

Figure 3. Segmented image

Komal Sharma, Akwinder Kaur and Shruti Gujral [8] presented a brain tumor detection using machine learning algorithm. The proposed work is divided into three parts. The first part is pre-processing are applied on brain MRI images. Then second is texture features are extracted using Gray Level Co-occurrence Matrix (GLCM). Classification is made using machine learning algorithm. The MRI brain tumor detection is difficult task due to density and difference of tumors. Automated tumor detection methods are developed as it would save time and MR images involves feature extraction and classification using machine learning algorithm. Proposed Method for Brain Tumor Detection in MR images consist of different steps, image acquisition, pre-processing, feature extraction and classification. The Machine learning algorithms are used for classification of MR brain image and get either as normal or abnormal. Feature is formed by using Multi-Layer Perceptron (MLP) and Naive Bayes for classification.

Neha Rani and Sharda Vashisth [9] implemented brain tumor detection and classification techniques using feed forward back-prop neural network. This work statistical analysis morphological and thresholding techniques are used to process the images obtained by MRI. The Feed-forward back-prop neural network is used for classification and to classify the performance of tumors part of the image.

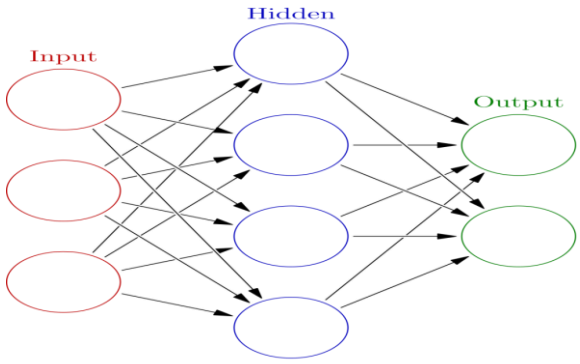

Figure 4. Multilayer feed forward back-prop neural network

Vrushali Borase, Gayatri Naik, Vaishali Londhe [10] proposed MRI based brain tumor detection technique using artificial neural network. This method uses computer based procedures to detect tumor blocks and classify the types of tumor using Artificial Neural Network Algorithm for MRI images of different patients. Different image processing techniques such as image segmentation, image enhancement and feature extraction are used for detection of the brain tumor in the MRI images of the cancer affected patients. The neural network techniques are used to improve the performance of detecting and classifying brain tumor in MRI images. The advantages of neural network system that take place from its ability to recognize and model nonlinear relationships between data. One of the important goals of Artificial Neural Networks is the processing of information similar to human interaction the neural network is used when there is a need for brain capabilities and machine idealistic.

Gladis Pushpa Rathi and Palani [11] explored MRI based brain tumor detection and classification using deep learning algorithm. In this method, tumor classification using multiple kernel-based probabilistic clustering and deep learning classifier is proposed. The proposed technique consists of three modules, segmentation, feature extraction and classification. MRI image is pre-processed to make it fit for segmentation and the median filter is user for de-noising process. Then, pre-processed image is used to segment using the technique called multiple kernel based probabilistic clustering (MKPC). Features are extracted for every segment based on the shape, texture and intensity, important features will be selected using Linear Discriminant Analysis (LDA). Deep learning classifier is employed for classification into tumor or non-tumor. And this technique is evaluated using sensitivity, specificity, accuracy. The proposed technique achieved an average sensitivity, specificity and accuracy.

Nicolas Coquery, Olivier Francois et al., [12] presented a micro vascular MRI and unsupervised clustering of histology resembling image models. This proposed technique is to construct histology-resembling images based on tissue micro vascularisation, a MRI accessible source of contrast. To integrate the large amount of information collected with micro vascular MRI, they combined a manual delineation of a spatial region of interest with an unsupervised, model-based

cluster analysis. This approach was applied to two rat models of glioma. In this model there are six MRI parameters are used. The first one is apparent diffusion coefficient, vessel wall permeability, cerebral blood volume fraction, cerebral blood flow, tissular oxygen saturation, and finally, cerebral metabolic rate of oxygen.

Lemasson, Pannetier et al., [13] implemented MRI based fingerprinting approaches for the brain tumor models. This technique they designed to provide high-resolution parametric maps of micro vascular architecture and function by using the evaluation of fingerprinting approach. The fingerprinting technique can forcefully differentiate between healthy brain tissues with dissimilar behaviours in tumor and stroke models. To study micro vascular properties of brain diseases use an efficient technique called MR vascular fingerprinting. Multiple improvements can be seen and might improve the disease diagnosis and prediction. In multidimensional approach the multiple dimensions is used to generate the fingerprints are not only obtained with MRI, but also other imaging modalities cab be used. Positron emission tomography or near infrared spectroscopy are the important modalities. It can provide a better vision of brain disorders.

Rohini and Regan [14] presented a feature extraction and abnormalities detection in brain tumors. Feature extraction is a one of the most important process is used to represent images in its reduced form. This proposed method is used to set the problem of classification of MRI brain images by creating strong and accurate classifier. Use some morphological operator feature selection method is proposed. And this method is more efficient for classification purpose and highly accurate to detect the tumor area in the MRI brain images. The noises in the images are removed by using filters. The morphological operation is made for classified images so the result become better and accurate.

Dena Nadir George, Hashem B. Jehlol, and Anwer Subhi Abdulhussein Oleiwi [15] implemented a brain tumor detection technique based on machine learning algorithms and shape features. The proposed method is used to detect the MRI brain tumor images. These images include different

number of steps called sigma filtering, adaptive threshold and detection region. Major axis length, minor axis length, solidity, Euler number, Circularity and area are the different numbers of shape features to be extracted for MR images. Two classifiers are used by proposed approach. C4.5 decision tree algorithm and MLP algorithm are the two classifiers. To check whether the brain case is normal or abnormal, the different classifiers are used for this purpose.

Table -1: Comparison of different brain tumor detection techniques

Sl No	Paper Title	Techniques Used	Advantages	Drawbacks
1	Image Analysis for MRI Based Brain Tumor Detection and Feature Extraction Using Biologically Inspired BWT and SVM	BWT based brain tumor segmentation SVM based classification	• Improve the performance and reduce the complexity involves in the medical image segmentation.	• Less Specificity. • BWT classifier takes more time to classify the results. • Depth analysis not included
2	Deep Learning for Brain MRI Segmentation: State of the Art and Future Directions	Deep learning-based segmentation	• Better random weight initialization of the network • Commonly used in machine learning and known as data augmentation.	• Generic method that will be robust to all variations in brain MR images from different institutions and MRI scanners is very challenging.
3	Brain MR Image Segmentation for Tumor Detection using Artificial Neural	Artificial Neural Network	• Improve the performance of detecting and classifying brain tumor in MRI images.	• The cost are more complexity in the modelling of the output image as a function of the input images
4	Brain Tumor Detection and Classification with Feed Forward Back-Prop Neural Network	Feed-forward back-prop neural network based classification	• Classifier reduces number of iterations detection, which reduces computation time	• Less specificity and sensitivity
5	MR Vascular Fingerprinting in Stroke and Brain Tumors Models	MR vascular finger printing	• There is no need to weigh the influence of "nuisance" parameters in order to improve.	• Quantification remains a challenge and results obtained in normal tissues are difficult to reproduce in pathological environments.

6	Extraction of Feature and Detection of Abnormalities in Brain Tumor	Morphological operator based feature selection	• More efficient in analysis of high classification and accuracy to detect the tumour area in the brain image.	• Estimating the probability density function of the underlying variable take more time.
7	The Multimodal Brain Tumor Image Segmentation Benchmark (BRATS)	Multimodal Brain Tumor Image Segmentation	• Automatically analyze brain tumor scan would be enormous potential value for improved diagnosis, treatment planning and follow-up of individual patients	• The slower growing low-grade variants, such as astrocytomas, come with a life expectancy of several years so aggressive treatment is often delayed as long as possible.
8	Detection of human brain tumour using MRI image segmentation and morphological operators	K-Means Clustering and morphological operators	• Better results were obtained with the application of morphological operators. • Reduced time for analysis	• The factor used in thresholding is very difficult to determine. • The watershed method is highly sensitive to local minima.
9	Brain Tumor Detection based on Machine Learning Algorithms	Multi-Layer Perceptron and Naïve bayes machine learning	• Automated tumor detection methods are developed, it is more accurate.	• The proposed algorithm takes more time to build the model.
10	Micro vascular MRI and unsupervised clustering yields histology-resembling images in two rat models of glioma	Unsupervised clustering	• The presence of a cluster within a tumor can be used to assess the presence of a tissue type	• Removing an MRI parameter from the analysis did not improve the overall tissue classification. • Imaging complex cancer lesions, which are heterogeneous in space and time, is a real challenge.

3. CONCLUSIONS

This paper revealed several tumor detection and classification techniques. Only few features are extracted during feature extraction process so the accuracy is low for tumor detection. Some classifiers take more time to classify the result. To improve the efficiency of classification accuracy and reduce the recognition complexity involves in the medical image segmentation process, proposed spearman based brain tumor segmentation. CNN based classifier used to compare the trained and test data, from this get the best result. The proposed technique have been evaluated and validated for classification performance on MR brain images, based on accuracy, sensitivity, and specificity.

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