A Survey of Computer-aided diagnosis of MRI-Based Brain Tumor Detection and Classification

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Abstract— **A Brain tumor is very meticulous diseases in the field of medical science that may leads to the deaths of affected person when it is not properly diagnosed at early stage. Detection and classification of brain tumor at right time enhances the probability of diagnostic method and treatment. As per the census, 1 out of every 1000 persons in India is subjected to have brain tumor. Brain tumors are formed due to the abnormal development of tissues inside the brain. The detection and Classification of tumor affected region of brain has been one of the most tedious process for the radiologists or clinical supervisors .Thus medical image processing approaches along with machine learning methodologies aids in diagnosis, pre-post surgical process include Computer-aided detection/diagnosis (CAD) systems to overcome the problem faced by the clinical diagnosing by enhancing the process for accurate detection and classification approaches. Magnetic Resonance Imaging (MRI), the most prudential and useful method for diagnosing the tumor. Good segmentation of brain MRI, have to provide a complete information about tumor and also classification from malignant to benign, which may be difficult due to its variation of gray intensities in tumor tissue. In order to solve the above stated problem, this review paper examines current practices, problems, and prospects of computer-aided detection and classification techniques for Brain tumor .The reason for studies on brain tumor not only helps for diagnosis purpose, also to provide a new avenue for explaining the strength and limitations of previously proposed classification techniques. The main aim of this survey paper is to clearly provide all current developments in the field of computer-aided diagnosis system for diagnosing the brain tumor and summarization of latest classification approaches and the techniques used for improving classification accuracy.**

Keywords—**Magnetic Resonance Imaging (MRI), Feature extraction, Segmentation, Classification.**

I. INTRODUCTION

A Brain tumor is one of the major causes for the increase in death among children and adults around the world. Brain tumor is a group of unnecessary and abnormal cells that grows inside of the brain which may be occupies within the skull as an intracranial lesion causes intracranial pressure [1]. Brain tumors are mainly classified as Benign (noncancerous) and Malignant (cancerous). The location of tumor can be diagnosed by means of imaging techniques used in medical field such as Computed Tomography (CT), Single-Photon Emission Computed Tomography (SPECT), Magnetic Resonance Imaging (MRI) and Magnetic Resonance Spectroscopy (MRS) which may provide a particulars about shape, size, location and gray level of brain tumors . Among various methods of diagnosis, most commonly available method is MRI, is a non-invasive in vivo imaging technique that uses radio frequency signals to focus the tissues that are affected under the view of magnetic field.

Magnetic Resonance Imaging (MRI) is based on emission of radio wave energy and magnet that will create an image that traces the structure, size of brain tumor and helps in treatment process accordingly [2]. In MRI image analysis of brain, the feature extraction must be done in order to reduce the dataset volume. Segmentation is a process of splitting an image into sub images or blocks which may be similar in terms of colour, contrast, brightness, and gray level. In MRI or other medical imaging techniques ,the Brain tumor segmentation is used for separation of the tumor tissues namely as edema and necrosis from other region brain of tissues, such as gray matter(GM), white matter (WM), and cerebrospinal fluid (CSF) [3–7].

Many researches proposed various feature extraction and classification method for detecting and diagnosing brain tumor which will be depicted in the further topics. This paper outlines the various techniques which are used for detection and classification of MRI scanned images of brain tumor. Various performance comparisons of the classification of brain tumor based on MRI are also reviewed.

II. Methodologies Used for Detection And Classification of brain tumor

Generalized frameworks for detecting and classifying the MRI Scan of Brain Image involve the following stages are observed in Fig 1.

A Methodologies used for detection and classification system can be divided into five stages: data acquisition, preprocessing, enhancement, feature extraction and classification. These sections are described below.

A. Data acquisition

The World Health Organization (WHO) classified the brain tumors in different types of about 120, based on the size, shape and characteristics of the tissues affected due to the presence of tumor tissue in brain [26]. The three most commonly known types of malignant tumors which are:

Glioblastoma , Sarcoma, Metastatic bronchogenic carcinoma. Collection of real brain images to make a research work is a very tedious and it is privacy issue. As of now most of the data are collected from the various sources [27-32]. Thus data acquisition is considered as most important part for the start of research work in medical image processing.

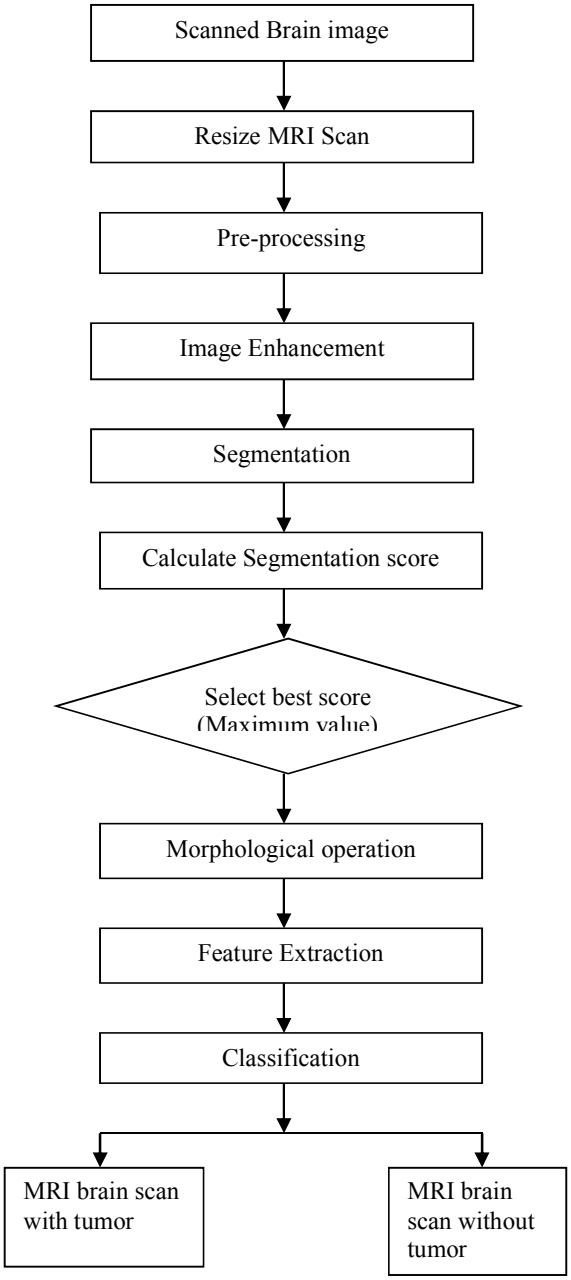


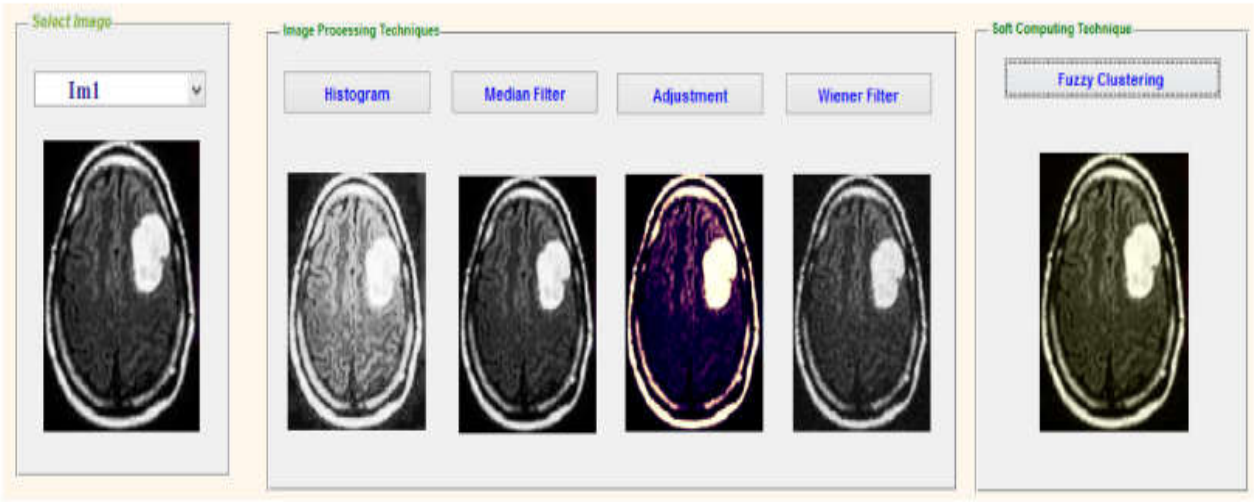
Fig. 1 Block diagram of MRI Brain tumor image methodology for detection and classification

B. Preprocessing and Image Enhancement

Generally, in biomedical image processing, it is important to remove the noise and artifacts for improving the resolution contrast the image. The pre-processing is used for improving the information present in the image according to the need of desired output.

Especially in scanning of brain image a wide range of artifacts, which may occur during the acquisition process [33]. The pre-processing level helps in removing these artifacts without losing important information. The MRI brain scanning preprocessing step involves the removal of these unwanted artifacts, improving the signal-to-noise ratio, removing the unwanted regions in the background, smoothing and sharpening the edges [34].

In addition to the pre-processing, it is important for enhancing the brain images which is mainly done by means of skull- Fig. stripping operation [35]. Some of the methods used in previous research works are skull stripping by obtaining the contour of the image, skull stripping using region growing and morphological operation, and skull stripping depending upon the histogram value (threshold value). The previously proposed enhancement technique with comparison is shown in Fig. 2.



2 Various Enhancement methods used for MR image

C. Image segmentation and Morphological Operation

Image segmentation is the difficult stage in MRI brain images which is used for separating the normal brain tissues from tumor tissues regions and this segmented tumor region is used for further level of process. There is different segmentation schemes are proposed earlier such as watershed segmentation [36, 37], Fuzzy C-means clustering segmentation [38], discrete cosine transform segmentation, genetic algorithm (GA) [39] etc. Based on the best score further classification process takes place. Fig. 3 depicted an example for segmentation using Fuzzy C Mean clustering

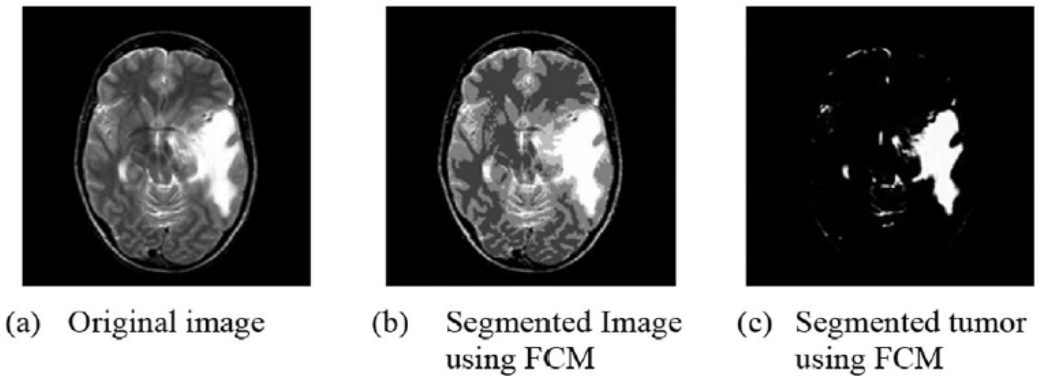


Fig. 3 Example of segmented tumor using Fuzzy C Mean clustering

The extraction of the boundary areas of the brain images can be achieved by morphological operation. Some of the basic morphological operation include opening, closing, boundary extraction, convex hull etc., but for the separation of tumor tissues from white matter thresholding is also used. Since white pixel has to be eliminated, erosion operation is executed.

D. Feature Extraction and Classification

The most complex problems in medical image analysis are the extraction of feature and classifying them into their respective classes. Features must be selected in such a way that it can is used for separating the different classes effectively. The most latest development in the field of image processing provided an efficient human brain Computer Aided Diagnosis(CAD) systems involves discreet wavelet transform (DWT) for decomposition of the MRI for getting the wavelet coefficients. For dimensionality reduction, Principal components analysis (PCA), independent components analysis (ICA) and linear discriminate analysis (LDA) are utilised. Features can extract from texture feature and its properties also. Extracted Features are provided as inputs to classifiers for assigning the image into their respective groups. The features are provided to classifier in the form of feature vector.

In previous works many classifiers has been employed for the classification of MRI brain tumor images. Some of the well known classifiers are Artificial neural network (ANN)[41] is a mathematical model possess learning capabilities for making use of pervious experimental knowledge by storing it and using it later, KNN algorithm make use of concept of distance metrics, Genetic algorithms (GA) are population based process to obtain approximate solution for optimization search problem, Support Vector Machine (SVM)[40]uses the hyper planes to provide a decision boundaries for separating data points into different

classes, Self-organizing network(SOM)[41] use statistically salient features of pattern vectors in data set for finding clusters in training data pattern space which can be used to classify new patterns

III. Related works for Detection And Classification of brain tumor

Various works has been proposed by many researchers for the detection and classification of tumor in MRI brain image. Some of the proposed work is provided below.

Swapnil R.Telrandhe ,Amit Pimpalkar and Ankita Kendhe [8] segmented brain tumor based on similarity algorithm and it is being classified using support vector machine (SVM)for pattern recognition. They have also used Object Labelling for feature extraction .The extracted features used to train SVM and it is used for pattern matching. They has obtained an accuracy of 92.3% on detecting the brain tumor.

Noramalina Abdullah, Lee Wee Chuen, Umi Kalthum Ngah and Khairul Azman Ahmad[9] provided a new technique using principal component analysis(PCA) method, to reduce the feature vector size in-order to increase accuracy percentage .The proposed work obtain a overall accuracy as 97%.

Aneja and Rawat [10] , in this paper Fuzzy clustering means (FCM) clustering algorithm is used for segmentation for reducing noise .The experimental results of the segmentation shows the Segmentation performance based on Comparative analysis of cluster validity functions, execution time and obtained non classification error of 0.537%, with an improved accuracy.

Nandagopal and Rajamony [11], this paper deals with the combined process of wavelet statistical features (WST) and wavelet co-occurrence texture feature (WCT) as different level discrete wavelet transform for the classification of tumor tissue. The entropy value of classification obtained from probabilistic neural network overcomes the pattern matching problem. The classification accuracy of the proposed method is 97.5%.

Zhao F, Liu H and Fan J [12], used Multi-objective spatial FCM to work against noisy images and they have used SVM for segmentation. In-order to select the optimal texture feature, Genetic algorithm is used. A neuro fuzzy classifiers is also used and obtained a accuracy of 98%.

Yudong Zhang, Zhengchao Dong , Lenan Wu, Shuihua Wanga,[13], in this paper, they have employed wavelet transform for feature extraction and principle component analysis (PCA) for dimensionality reduction. The obtained feature vector is used as feedback for back propagation (BP) Neural network, scaled conjugate gradient (SCG) is also adopted to get the optimal weights. The classification accuracy y is 100% with low computation time.

Evangelia I. Zacharaki, Sumei Wang, Sanjeev Chawla, Dong Soo Yoo, Ronald Wolf, Elias R. Melhem, Christos Davatzikos,[14] , in this paper various levels of segmentation of brain tumor has been employed such as definition of region of interest from scanned image , extraction of feature ,selection of feature and classification. The feature extraction mainly based on shape, size and intensity a characteristic which depends on rotation invariant texture features. Support Vector machines (SVMs) are performed for classification and obtained accuracy, sensitivity, and specificity, 87%, 89%, and 79% respectively which is validated by leave-one-out cross-validation process.

G Pantelis georgiadis, Dioisis cavouras,Menelaos Malamas [15] , proposed a scheme that use a Modified Probabilistic Neural Network classifier (PNN) for separating the brain tumor tissue rest of the region on MRI. The scheme provided a high speed computation ability and better recognition rate comparatively with other classifiers.

Y. Zhang, L. Wu[16],they proposed classification methodologies for classifying the MR image as tumor affected or not affected , with the help of wavelet transform for extraction of feature from images. The dimension of the feature vector is reduced by applying principle component analysis (PCA). A generalized of Kernel support vector machine with K fold methods is observed to achieve good accuracy of about 98.7%.

Praveen, Amritpal Singh[17] the proposed method based on the combination of support vector machine (SVM) and fuzzy c-means for brain tumor classification. For enhancement of the image some of the methods namely Contrast improvement, mid-range stretch and morphological operations are used. Segmentation based on fuzzy c-means clustering and SVM for classification are employed. The proposed method acquired accuracy as 97%.

Deepa and Devi [18] ,this paper mainly concentrated on classification of brain image as cancerous or non-cancerous as an automatic method by making use of advantages of back propagation (BP) and Radial Basis Function (RBF) neural network function .

Mahmoud Khaled Abd-Ellah, Ali Ismail Awad, Ashraf A. M. Khalaf, and Hesham F. A. Hamed[19] , in this paper feature extraction has been obtained from discrete wavelet transform (DWT) . For segmentation K-means clustering and for classification support vector machine (SVM) are utilized for improving the accuracy. The Performance evaluation of the proposed computer aided diagnosis of brain tumor gave good proven results.

R.Lavanyadevi, M.Machakowsalya, J.Nivethitha, A.Niranjil Kumar[20],the proposed method used neural network for classifying brain tumor as benign or malignant .Features of the MRI brain image are extracted by means of the Gray Level Co-Occurrence Matrix (GLCM). Classification mainly depended on probabilistic neural network (PNN) and they have observed that PNN is fastest classifier to get good classification accuracy.

El-Dahshan et al [21] proposed a methodology in the form of hybrid technique consists of different levels like feature extraction using Discrete Wavelet Transform (DWT), dimensionality reduction done by Principal Component Analysis (PCA)and classification based on feed forward back propagation artificial neural network (FP-ANN) for the classification of Magnetic Resonance Images (MRI). The proposed method also compared their work with other classifier .A classification of 97% has been obtained.

Damodharan S, Raghavan D [22], has proposed a novel method using Linear Discriminant Analysis to classify of brain tumor.This Linear Discriminant Analysis consists of data (image)collection, Normalization, Texture feature extraction, feature selection and classification. The result based on the above method has been reduced with the help of Principal Component Analysis (PCA) and they acquired classification accuracy as 98.87% from Support Vector Machine (SVM).

Padmakant Dhage, Prof. M.R.Phegade, Dr.S.K.Shah [23], in their paper for segmentation process an unique technique namely watershed segmentation algorithm has been utilized for partitioning the abnormal tissue from the brain. This paper also dealt with the process to find extract position and shape of tumor observed from MRI by calculating some parameters like perimeter, eccentricity, entropy and centroid.

Various methods for MRI brain tumor image detection and classification are summarized in Table I with its performance metrics which may help the researchers for their works.

TABLE I
FEATURE EXTRACTION AND CLASSIFICATION TECHNIQUES PERFORMANCE COMPARISON

Name of researchers	Year	Processing techniques	Classifier	Performance metrics
Maitra and Chatterjee[42]	2008	Improved orthogonal DWT	Fuzzy C-means (FCM) clustering	Accuracy:100 %
Zacharaki et al[43]	2009	Manual feature extraction, ,Constrained Linear Discriminate Analysis (CLDA)	SVM	Accuracy :85% Specificity:87% Selectivity:79%,
El-Dahshan et al.[44]	2010	DWT, PCA	Feed forward back propagation artificial neural network (FPANN), k-NN	Accuracy :97%
Kharrat et al. [45]	2010	Texture feature extraction	Ensemble base classifier, SVM and ANN	Accuracy :99%
Zhang et al. [46]	2011	Wavelet transform ,PCA	Back propagation neural network (BPNN)	Accuracy :100%
Zollner et al. [47]	2012	(i) Pearson's correlation coefficients (PCC), (ii) PCA and (iii) independent component analysis (ICA)	SVM , PCA	Accuracy :82%
Bahadure et al. [48]	2016	Watershed segmentation and FCM	ANN	Accuracy :85%
Torheim et al.[49]	2014	Texture feature extraction	SVM	Accuracy :95% Specificity:87% Selectivity:79%,
Ankit Vidyarthi et al [50]	2016	DWT(Discrete wavelet transform)	K-nearest neighbor	Accuracy :93%
sandip chaplot et al [51]	2006	DWT	SVM , ANN	Accuracy :97.33%
Badameh A. et al. [52]	2012	Wavelet,PCA	ANN	Accuracy :98.92%
V.Anitha et al . [53]	2015	DWT	Enhanced cosine RBFNN	Accuracy :85% Specificity:96% Selectivity:94%,
S.k.Shil et al .[54]	2002	DWT,PCA	K -means,SVM	Accuracy :99.33%
Y.Zang et al [55]	2012	DWT ,PCA	kernel SVM , Gaussian radial basis	Accuracy :99.38%
M.Saritha et al [56]	2013	DWT , wavelet entropy (WE) , spider web plots ,PNN	Decision-tree classifier, k-fold cross validation (CV) process	Accuracy :99.8%
El-Sayed A. El-Dahshan a et al [58]	2014	feedback pulse coupled NN ,DWT , PCA	FP-ANN	Accuracy :98.8%
Jayalaxmi S Gonal et al [59]	2015	Wavelet,GLCM	K means ,SVM	Accuracy :98%
Paulin John et al [60]	2012	Wavelet,GLCM+PNN	SVM	Accuracy :98%
Evangelia I. Zacharaki et al [61]	2009	Invariant texture	SVM	Accuracy :87% Specificity:83% Selectivity:96%,
Noramalina Abdullah et al [62]	2011	Wavelet,PCA	SVM	Accuracy :85%

Yudong Zhang et al [63]	2011	Wavelet	ANN	Accuracy :98%

IV. CONCLUSIONS

With the development in the field of medical image processing which includes computational intelligence and machine learning techniques, computer-aided detection and classification for brain tumor has been increasingly popular among the researchers. This paper reviewed previous works of the different segmentation, feature extraction and classification algorithms for processing of MRI brain images.

After summarizing some of the evaluation technique it may provide an idea for using various methods which can detect the tumor efficiently for providing good result. The comparative analysis is also provided for improving the classification accuracy. There are still many researches have to be done to utilize other machine learning methodologies and to combine them into a hybrid system.

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