



An Automatic Brain Tumor Detection and Segmentation Scheme for Clinical Brain Images

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Abstract: Brain tumour is an abnormal growth of brain cells within the brain. Detection of brain tumour is a challenging problem, due to complex structure of the brain. The automatic segmentation has great potential in clinical medicine by freeing physicians from the burden of manual labelling; whereas only a quantitative measurement allows to track and modelling precisely the disease. Magnetic resonance (MR) images are an awfully valuable tool to determine the tumour growth in brain. But, accurate brain image segmentation is a complicated and time consuming process. MR is generally more sensitive in detecting brain abnormalities during the early stages of disease, and is excellent in early detection of cases of cerebral infarction, brain tumours, or infections. In this research we put forward a method for automatic brain tumour diagnostics using MR images. The proposed system identifies and segments the tumour portions of the images successfully.

Keywords: Brain Tumour; Magnetic Resonance Image; Segmentation; Feature extraction; Computer Tomography; Malignant; Medical image processing; clinical images

I. Introduction

The theme of medical image segmentation is to study the anatomical structure, identify the region of interest ie. Lesions, abnormalities, measure the growth of diseases and helps in treatment planning. Segmentation of brain into various tissues like gray matter, white matter, cerebrospinal fluid, skull and tumor is very important for detecting tumor, edema, and hematoma. For early detection of abnormalities in brain parts, MRI imaging technique is used. Particularly, MRI is useful in neurological (brain), musculoskeletal, and ontological (cancer) imaging because it offers much greater contrast between the diverse soft tissues of the body than the computer tomography (CT). According to the World Health Organization, brain tumor can be classified into the following groups:

Grade I: Pilocytic or benign, slow growing, with well defined borders.

Grade II: Astrocytoma, slow growing, rarely spreads with a well defined border.

Grade III: Anaplastic Astrocytoma, grows faster.

Grade IV: Glioblastoma Multiforme, malignant most invasive, spreads to nearby tissues and grows rapidly.

A group of abnormal cells grows inside of the brain or around the brain causes the brain tumor. It can be benign or malignant; where benign being non-cancerous and malignant is cancerous. Malignant tumors are classified into two types, primary and secondary tumors. Benign tumor is less harmful than malignant. Malignant tumor spreads rapidly invading other tissues of brain, may progressively worsening the condition causing death. Brain tumor detection and segmentation is very challenging problem, due to complex structure of brain. The exact boundary should be detected for the proper treatment by segmenting necrotic and enhanced cells [1]. In automated medical diagnostic systems, MRI (magnetic resonance imaging) gives better results than computed tomography which provides greater contrast between different soft tissues of human body [18]. Computer-based brain tumor segmentation needs largely experimental work. Many efforts have exploited MRI's multi-dimensional data capability through multi-spectral analysis. Existing manual brain MR images detection entails abundance of time, non-repeatable task, and non-Uniform division and also outcome may vary from expert to expert. The Edge-based methods are focused on detecting contours of brain regions. They fail when the image is blurry or too complex to identify a given border. Cooperative hierarchical computation approach uses pyramid structures to associate the image properties to an array of father nodes, selecting iteratively the point that average or associate to a certain image value. The Statistical approaches label pixels according to probability values, which are determined based on the intensity distribution of the image. With a suitable assumption about the distribution, statistical techniques attempt to solve the problem of estimating the associated class label, given only the intensity for each pixel. Such estimation problem is necessarily formulated from an established criterion of experimentation. Artificial Neural Networks based image segmentation techniques are originated from clustering algorithms and pattern recognition methods. They usually aim to develop unsupervised segmentation algorithm.

Region-based segmentation is the concept of extracting features (similar texture, intensity levels, homogeneity or sharpness) from a pixel and its neighbors is exploited to derive relevant information for each pixel. So computer aided system is useful in this context. Detection of brain tumor necessitates brain image segmentation. A automatic brain tumor detection system segmentation should take less time and should classify the brain MR image as normal or tumorous perfectly. It should be consistent and should supply a system to radiologist are of, self-explanatory and simple to operate [21].

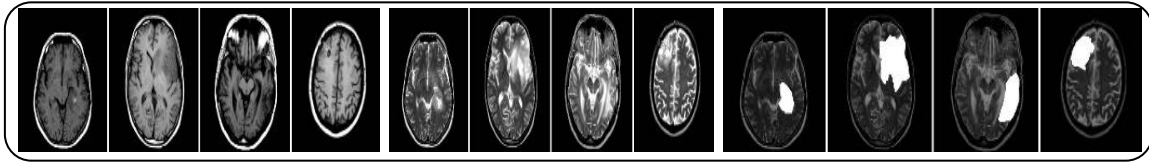


Fig. 1. Brain Tumor image

Normally, there are three common types of tumor, which are Benign, Pre-Malignant, and Malignant. A benign tumor is a tumor is the one that does not expand in an abrupt way; it doesn't affect its neighboring healthy tissues and also does not expand to non-adjacent tissues. Moles are the common example of benign tumors. Pre-Malignant Tumor is pre-cancerous stage, which may consider as a disease. If not treated properly, it may lead to cancer. Malignant tumor is a term which is typically used for the description of cancer .Malignancy (mal- = "bad" and -ignis = "fire") is the type of tumor, that grows worse with the passage of time and ultimately results in the death of a person. Malignant is basically a medical term that describes a severe progressing disease. [8]

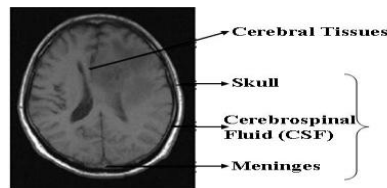


Fig. 2. Brain Image Details

II. Literature Review

MRI is basically used in the biomedical systems, to detect and visualize finer details in the internal structure of the body. It is used in cancer detection, staging, therapy response monitoring, biopsy guidance and minimally invasive therapy guidance. Imaging techniques that have been developed to image cancer are based on relaxivity-based imaging with and without contrast agents, perfusion imaging using contrast agents, diffusion weighted imaging, endogenous spectroscopic imaging, exogenous spectroscopic imaging with hyperpolarized contrast agents, magnetic resonance elastography and blood oxygen level determination (BOLD) imaging. This technique basically used to detect the differences in the tissues, which is a far better technique as compared to computed tomography. So, this makes this technique a very special one for the brain tumor detection and cancer imaging. [19]. A broad classification of present day tumor detection methods include histogram based, edges based, region based, cluster based and histogram based. A deformable registration method registers a normal brain atlas with images of brain tumor patients. It is computationally more expensive biomechanical model by Evangelia I.Zacharaki*, Dinggang Shen [11]. Anam and Usman use automatic brain tumor diagnostic system from MR images. The system consists of three stages to detect and segment a brain tumor. [8] Riries Rulaningtyas and Khusnu Ain propose an edge detection method for brain tumor with Robert, Prewitt, and Sobel operators. From these three methods, they suggest sobel method is more suitable with all the case of brain tumors [16]. Feng-Yi Yang and Shih-Cheng Horng developed a scheme to evaluate the permeability of the blood-brain barrier (BBB) after focusing ultrasound (FUS) exposure and they investigate if such an approach increases the tumor-to-ipsilateral brain permeability ratio [6].

Magdi et al [2] used an intelligent Model for brain tumor diagnosis from MRI images .which consist of three different stages such as preprocessing, Feature extraction and classification. Preprocessing used to reduce the noise by filtration and to enhance the MRI image through adjustment and edge detection .texture features are extracted and principal component analysis (PCA) is applied to reduce the features of the image and finally back propagation neural network (BPNN) based Person correlation coefficient was used to classify the brain image. N.senthilal kumaran, et al [7] presented a hybrid method for white matter separation from MRI brain image that consist of three phase. First phase is to preprocess an image for segmentation, second phase is to segment an image using granular rough set and third phase is to separate white matter from segmented image using fuzzy sets This method was compared with mean shift algorithm and it was found that hybrid segmentation performs better result . The researcher [17] presented a method to detect and extract the tumor from patients MRI image of brain by using MATLAB software. This method performs noise removal function, Segmentation and

morphological operations which are the basic concept of image processing. Tumour is extracted from MRI image for this it has an intensity more than that of its background so it becomes very easy locates. Mehdi Jafri and Reza Shafaghi [9] proposed a hybrid approach for detection of brain tumor tissue in MRI based on Genetic algorithm (GA) and support vector machine (SVM). In the preprocessing stage noise is removed and contrast is enhanced. For removing high frequency noises low pass filter is used for enhancing histogram stretching method is used. in segmentation undesired tissue such as nose, eyes and skull are deleted and features are extracted by different ways like FFT, GLCM and DWT. In feature selection GA is used with PCA by using this calculations complexity is reduced. Finally the selected features are applied to SVM classifier used to classify the image into normal or abnormal. A sivaramkrishnan [3] presented a novel based approach in which Fuzzy Cmean (FCM) clustering algorithm was used to find the cancroids of cluster groups to obtained brain tumor patterns. It is also preferred as faster clustering by using this cancroids point can be located easily. The histogram equalization calculates the intensity of gray level image and PCA was used to reduce dimensionality of wavelet coefficient.

An automatic brain tumor detection and Segmentation scheme for clinical brain modified image segmentation techniques, which were applied on MRI scan images, in order to detect brain tumors. The classification is performed on proton Magnetic Resonance Spectroscopy images. But the Classification accuracy results are different for different datasets which is one of the drawbacks of this approach by Pankaj Sapra, Rupinderpal Singh, Shivani Khurana [4]. Dina Aboul Dahab, Samy S. A. Ghoniemy, Gamal M. Selim implemented based on a modified Canny edge detection algorithm to Identify and Detect Brain Tumor [5]. Ahmed Kharrat and Mohamed Ben Messaoud reduce the extraction steps through enhancement the contrast in tumor image by processing the mathematical morphology. The segmentation and the localization of suspicious regions are performed by applying the wavelet transforms. [10]. Deepak .C, Dhanwani and Mahip M. Bartere analyze various techniques to detect Brain Tumour Detection from MRI image [1]. Wareld et al. [14, 15] combined elastic atlas registration with statistical classification. Elastic registration of a brain atlas helped to mask the brain from surrounding structures. A further step uses distance from brain boundary" as an additional feature to improve separation of clusters in multi-dimensional feature space. Initialization of probability density functions still requires a supervised selection of training regions. The core idea, namely to augment statistical classification with spatial information to account for the overlap of distributions in intensity feature space, is part of the new method presented in this paper. Leemput et al. [13] developed automatic segmentation of MR images of normal brains by statistical classification, using an atlas prior for initialization and also for geometric constraints. A most recent extension detects brain lesions as outliers [12] and was successfully applied for detection of multiple sclerosis lesions. Brain tumors, however, can't be simply modeled as intensity outliers due to overlapping intensities with normal tissue and/or significant size.

III. Methodology

The proposed system consists of four major stages to detect and segment tumor from brain images. They prominent stages are pre-processing, feature extraction and target segmentation and post-processing. The following figure shows the scheme of the proposed methodology. The following figure 4, describes the details of the proposal more clearly.

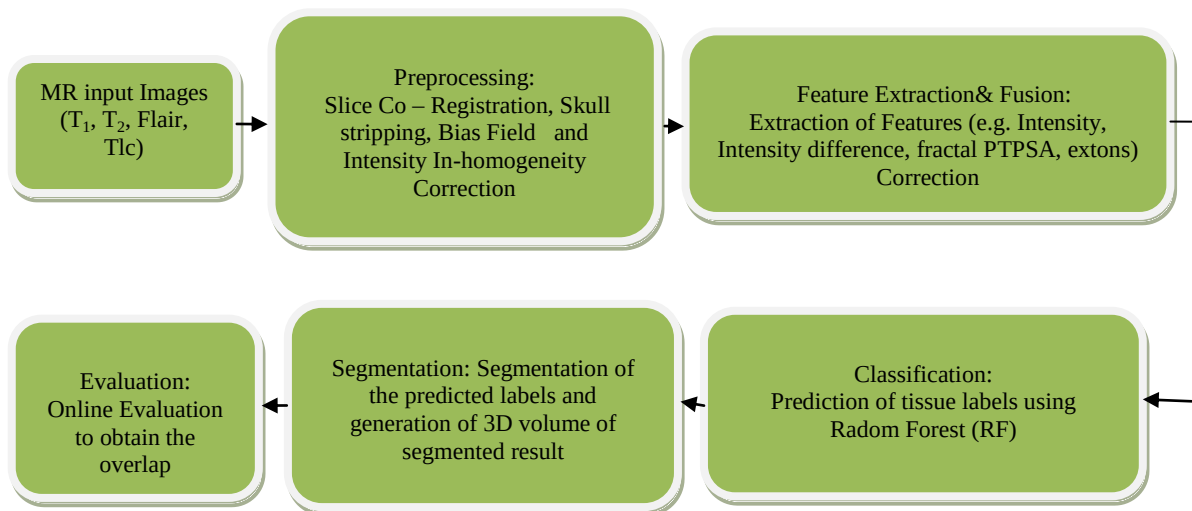


Fig.3. Schematic diagram of proposed method

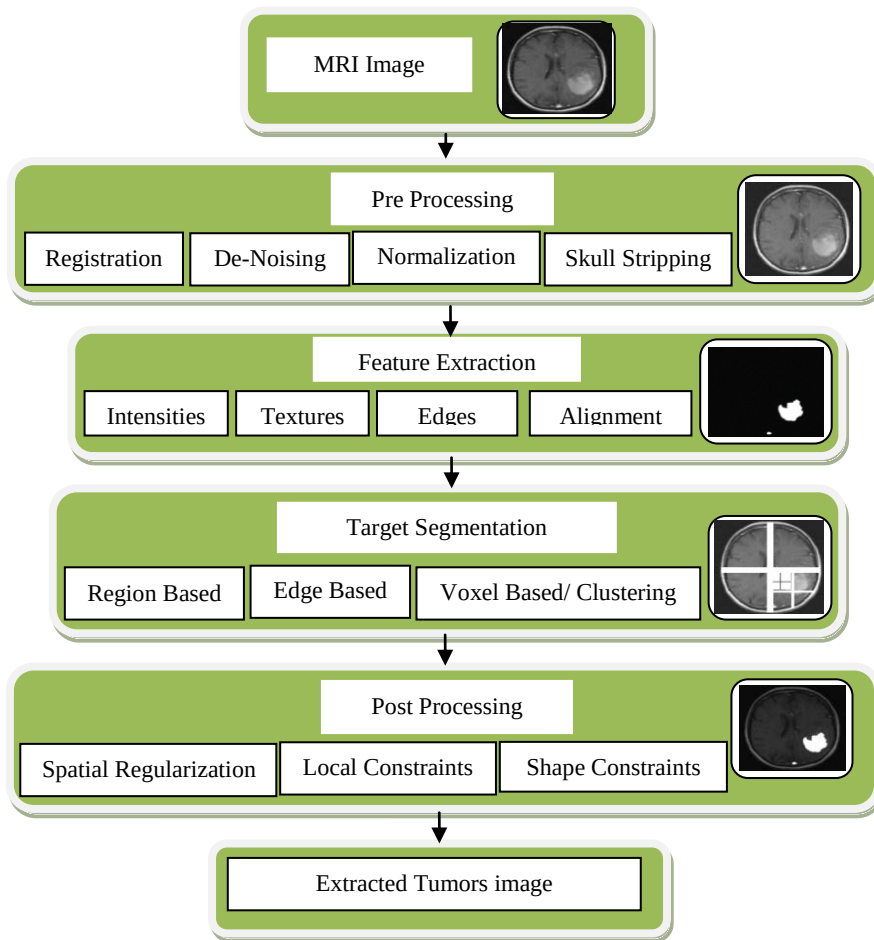


Fig. 4. Flow diagram of proposed method

A. **Preprocessing**

The preprocessing of brain MR image is the first step in our proposed technique. The preprocessing of an image is done to reduce the noise by a 3x3 median filter and to prepare the brain MR image for further processing. The purpose of these steps is basically to improve the image appearance and the image quality to get more surety and ease in detecting the tumor [14,15].

B. **Feature Extraction**

This feature extraction stage analyzes the objects from the input image, to extract the most prominent features that are representative of the various classes of objects. The features are used as inputs to classifiers that assign them to the class that they represent. The purpose of feature extraction is to reduce the original data by measuring certain properties, or features, that distinguish one input pattern from another pattern. The extracted feature should provide the characteristics of the input type to the classifier by considering the description of the relevant properties of the image into feature vectors. In this proposed method we are interested to extract the following features.

- Shape Features - circularity, irregularity, Area, Perimeter, Shape Index
- Intensity features – Mean, Variance, Standard Variance, Median Intensity, Skewness, and Kurtosis
- Texture features – Contrast, Correlation, Entropy, Energy, Homogeneity, cluster shade, sum of square variance.

The efficacy of texture based tumor detection, segmentation and classification has been discussed [2][9] to characterize the tumor surface variation which is expected to be different from the non tumor region , which further increases the certainty of fine extraction.

C. **Target Segmentation**

After improving the brain MR image, the next step of our proposed technique is to segment the brain tumor MR image. Segmentation is done to separate the image foreground from its background. Segmenting an image also saves the processing time for further operations which has to be applied to the image [16, 17].

D. **Post processing**

After segmenting the brain MR image, several post processing operations are applied on the image to clearly locate the tumor part in the brain which are given in the above flowchart. They mainly show part of the

image which has the tumor, which is the part of the image having more intensity and more area. These post-processing operations include spatial Regularization, strains and Shape Constraints.

IV. Results and Discussion

The accuracy and usefulness of the methodology is measured through the metrics used for the application. The important metrics used in this research are listed below. From the metrics chosen and visual appearance the proposal outperforms the other peer methods followed by current researchers [18, 20].

$$\text{Variance} : \sigma^2 = \sum_{i=0}^{G-1} (i - \mu)^2 P(i)$$

$$\text{Mean} : \mu = \sum_{i=0}^{G-1} iP(i)$$

$$\text{Sensitivity} = \frac{TP}{TP + FN}$$

$$\text{Specificity} = \frac{TN}{FP + TN}$$

$$\text{Accuracy} = \frac{TP + TN + FP + FN}{TP + TN + FP + FN}$$

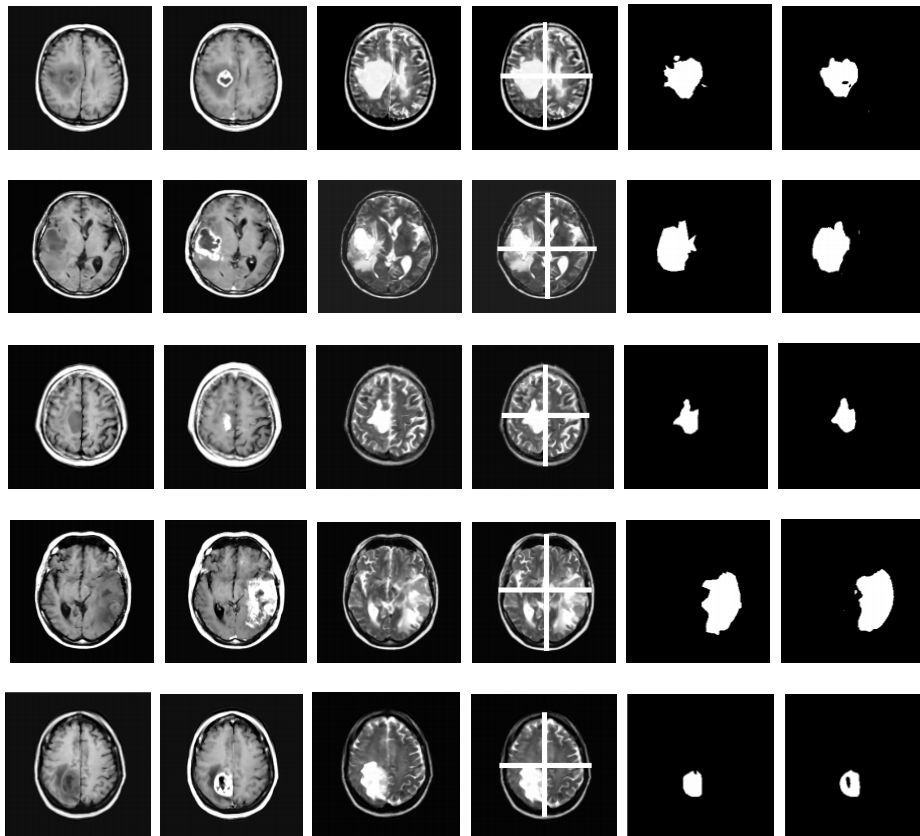


Fig. 5. T1(Weighted), T2(weighted), T1(Weighted) after contrast enhancement, Region based segmentation Manual labeling (Enhancing tumor area), Segmented and Enhanced tumor area

Table I Different Metrics to Detect Brain Tumor

Metrics		Dice			Kappa			Jaccard			Sensitivity			Specificity		
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
HG	M	.83	.70	.75	.99	1	1	.72	.58	.63	.80	.64	.74	.87	.85	.80
	S	.08	.24	.16	0.0	0	0	.12	.25	.18	.13	.28	.20	.07	.13	.14
LG	M	.72	.47	.21	.99	1	1	.58	.33	.17	.78	.42	.24	.72	.70	.20
	S	.17	.23	.35	0.0	0	0	.19	.19	.28	.22	.26	.38	.14	.30	.35
All	M	.79	.62	.57	.99	1	1	.67	.50	.47	.80	.57	.57	.82	.80	.60
	S	.13	.26	.35	0.0	0	0	.15	.26	.31	.16	.29	.36	.12	.21	.37

LG- Low Grad HG- High Grad S- Standard Deviation M Mean Value 1-Complete Tumor 2. Tumor Core 3. Enhancing Tumor

Table II Different Metrics to Detect Brain Tumor

S.No	Patient	Score (Including Boundary)	Score (Excluding Boundary)	Time
1	1	0.66	0.70	1
2	1	0.95	1.00	1
3	2	0.79	0.93	1
4	2	0.85	0.97	2
5	3	0.84	1.00	1

6	4	0.78	0.84	2
7	5	0.65	0.80	2
8	5	0.80	0.88	2
9	5	0.90	0.99	3
10	5	0.86	0.97	1
11	7	0.79	0.90	1
12	7	0.59	0.88	1
13	8	0.88	1.00	2
14	8	0.93	0.97	2
15	10	0.94	1.00	2
16	11	0.89	1.00	2
17	12	0.92	0.98	3
18	13	0.79	0.94	3
Average		0.82	0.95	1.78

V. Conclusion

In this paper, brain tumor segmentation is performed through a novel methodology. The proposed method is invariant in terms of size, segmentation and intensity of brain tumor. Experimental results show that the proposed method performs well in enhancing, segmenting and extracting the brain tumor from MRI images. The usage of discriminative features helps to classify the structural elements into normal and abnormal tissue that can reduce the complexity of the further. Finally it is concluded that the result of the present study are of great importance in the brain tumor detection which is one of the challenging tasks in the medical image processing. This work will be extended for new class of algorithms for brain tumor detection which will provide more efficient results than existing methods for the forthcoming researchers and scientists.

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