Enhanced Implementation of Brain Tumor Detection using MRI

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Abstract

The primary aim of this paper is to improve the technique of brain tumor detection in order to provide more accuracy in tumor monitoring thereby enhancing the overall treatment. Brain tumor is one of the major cause of death of human beings. If the tumor is detected as early as possible there are high chances of survival in humans. Through this paper, we are trying to make a scenario possible for diagnostics, by creating an application which implements the concept of image segmentation, clustering, extraction and detection which will eventually present resultant data to the end user as well as diagnostics in the form of report enabling them to know about whether it is a tumor and if it a tumor then at what stage it is now. Image segmentation performs partitioning of an image into mutually exclusive regions. This article mainly emphasizes on detection of approximate location of tumor, and its stage. The algorithm will require 2D MRI of brain, which will be segmented into 2 parts i.e. left and right.
Keywords: clustering, segmentation, brain tumor, region, processing, detection, analysis

I. INTRODUCTION

Human brain consists of cells and tissues. In normal situations cells naturally grow and eventually die, which are further replaced by new cells. But it might happen that old cells never die and new cells grow on it which results in Tumor. Tumor cells are those cells which are not required by our body. A brain tumor is a mass or growth of abnormal cells in your brain or close to your brain. How quickly a brain tumor grows can vary person to person with respect to tumor type, patient's age. The function of your nervous system will be affected by the growth rate as well as location of the tumor. There are two types of tumor: Primary tumor which is formed by the cells of brain itself and another one is secondary tumor which spreads from other part of body to brain. Initially the use of computers in medical field was for billing and administrative purpose only.

Now a days they are mostly used for generating laboratory reports. Detection of tumor is one of the most tedious jobs for diagnostics rather than any other disease detection. Image processing is most useful technique for advancement of human perception. The main purposes of image segmentation are :

1) Improving pictorial data in order to enhance human perceptions.
2) Processing of image data for storage and conversion.

With the increasing availability of relatively inexpensive computational resources such as magnetic resonance imaging (MRI), CT scan more reliable detection and diagnosis of disease can be achieved.

MRI: A large machine linked with a strong magnet to a computer is used to take detailed pictures of areas inside your head. Sometimes a special dye (contrast material) is injected into a blood vessel in your arm or hand to help show differences in the tissues of the brain. The pictures can show abnormal areas, such as a tumor.

Pattern recognition is main aspect of the system. Since tumor shape varies from person to person along with its type, it is required to use other properties of brain along with pattern recognition such as extraction. It consists of following steps:

1) MRI pre-processing;
2) selection of Region Of Interest(ROI);
3) brain skull detection;

4) Segmentation of tumor;
5) stage classification.

If we take MRI of patient at regular interval of time, we can also predict the growth rate of the tumor which might be not possible with traditional systems. The proposed system will give nearly accurate result of tumor detection with its stage.

II. PROPOSED WORK

The input to the system will be a 2D MRI which will be examined by the system for tumor detection. The first step will be extraction of brain skull from image. After extraction, asymmetric parts of image are detected and decision will be taken regarding which half of brain contains tumor is made.

A. Pre-Processing:

The images are pre-processed following a number of steps including noise reduction, bias-field correction.

B. Brain Skull Extraction:

Brain skull extraction of MRI is nothing but separation of MRI into region of brain and non-brain region which is required for analyses of neuroimaging data. Brain skull extraction plays major role in analysis since it is required to isolate brain region from non-brain region before applying processing algorithms. MRI may often contain some non-brain tissues such as skin, muscle, fat etc. Which is not necessary for brain tumor detection as well as it can increase overhead for system. Brain skull extraction is quite difficult and time consuming as there lies thin boundary between brain and non-brain tissues and complexity of human brain anatomy. There are various algorithms available for brain extraction but choosing the right one can affect further steps. Boesen et al. compared the performance of four BEAs and concluded that the brain extraction tool (BET) and the brain surface extractor (BSE) was significantly faster than the statistical parametric mapping(SPM) or Minneapolis consensus strip(McStrip).

The proposed brain extraction method consists of following steps: 1) Estimation of image intensity and calculation of binary image head for segmenting. 2) Initial contour is determined within brain region. 3) Geometric active contour model applied in order to extract brain region. The result of brain extraction is as follows:

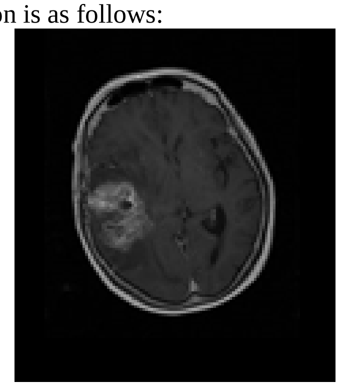

Fig. 1: Original MRI

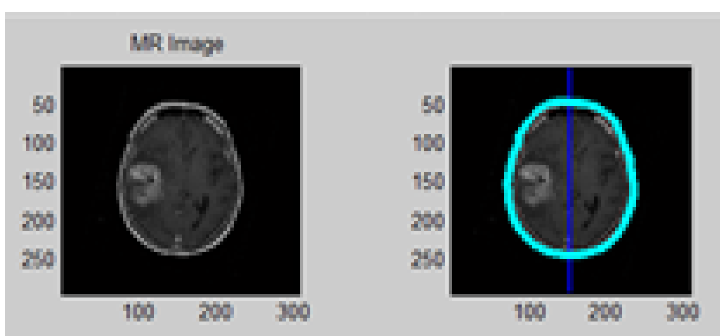

Fig. 2: Brain Skull Detection

Initially small rectangles whose sides are parallel to image sides are detected. Initial mask is set to these rectangles in order to assure whole skull is inside the mask. Then above method applies. Later on head is assumed to be symmetric and rectangle is divided into half.

Though the mask will not be precise since there are some cases where eyes might be present inside brain mask because of unclear boundary between eyes and brain, it will not affect result of system as asymmetries aroused by tumor are much higher than it.

C. Detection for Asymmetry in MRI:

The main focus of the system is to detect any asymmetry caused by tumor in MRI. The asymmetry can varies from swallowing of brain tissues to the tumor which will be identified by the system.

First of all system will divide the mask of brain in two equal parts vertically i.e. along the symmetric axis. Symmetric axis allows segmentation of detected brain image into two equal parts of same size. A square block of side length equal to ¼ of longer side of image is generated. The algorithm will go through both segmented part of brain mask symmetric to this block. Step size must be smaller than block size in order to ensure overlapping of particular areas. This areas will be compared with its symmetric opposite part. Comparing will be performed using Bhattacharya Coefficient.

The Bhattacharyya distance is widely used in research of feature extraction and selection, image processing, speaker recognition, phone clustering. A "Bhattacharyya space" has been proposed as a feature selection technique that can be applied to texture segmentation. The Bhattacharyya coefficient is an approximate measurement of the amount of overlap between two statistical samples. The coefficient can be used to determine the relative closeness of the two samples being considered. Calculating the Bhattacharyya coefficient involves a rudimentary form of integration of the overlap of the two samples. The interval of the values of the two samples is split into a chosen number of partitions, and the number of members of each sample in each partition is used in the following formula,

$$BC(\mathbf{p},\mathbf{q}) = \sum_{i=1}^{n} \sqrt{p_i q_i},$$

Eq 1: Bhattacharya Equation

Where n denotes number of bins in histogram and p and q are samples. P_i and q_i denotes histograms of block in left and right half. The values in Bhattacharya Coefficient ranges from 0 to 1. Next Computation for asymmetry will be computed using following formula,

$$As = 1 – BC$$

Where As denotes asymmetry caused by tumor. Asymmetry for all blocks will be computed along with global maximum. The output of this process will be mask containing clearly visible asymmetric parts of brain. Resultant mask is applied to input image and this image sent for detection.

D. Location of Tumor:

After detecting asymmetry it is required to locate position of tumor. Tumor might be either in left or right part of brain. Location of tumor can be achieved using computation of mean of the region. Another method for locating tumor can be, normalized histograms will be computed from both parts and rest of the brain. Using Bhattacharya Coefficient histograms of both area will be compared with rest of brain. Area having less similar histogram will be treated as region containing tumor.

The system was tested with three types of images i.e. 1) Image containing tumor 2) Image without tumor 3) Images that does not contain skull i.e. images other than brain images. In case of 1 and 2, whether the tumor is present or not is given by the system. If the image is other than brain image then it will give error indicating skull not detected.

Various shapes, location were tested. Since the tumor tissues keeps on growing continuously, it presses other parts in brain. Due to which asymmetry caused not only in tumor location but with adjacent parts and eventually affects the whole brain.

E. Classification:

Three pattern classification methods were investigated for comparison: LDA with Fisher's Discriminant Rule, k-Nearest Neighbor (k-NN), and nonlinear SVMs. In LDA, a transformation function is sought that maximizes the ratio of between-class variance to within-class variance. Since usually there is no transformation that provides complete separation, the goal is to find the transformation that minimizes the overlap of the transformed distributions. k-NN classification is performed based on closest training examples in the feature space. In SVMs, the original input space is mapped into a higher dimensional feature space in which an optimal separating hyperplane is constructed such that the distance from the hyperplane to the nearest data point is maximized. Due to this property, SVM classifiers tend to possess good generalization ability.

We applied leave-one-out external cross-validation in classifying meningioma (MEN), glioma of grade II, III, and IV (GL2, GL3 and GL4, respectively), and metastasis (MET) by applying three different classification methods (LDA, kNN, non-linear SVM) and two feature ranking methods (t-test with bagging, CLDA).

III. RESULTS

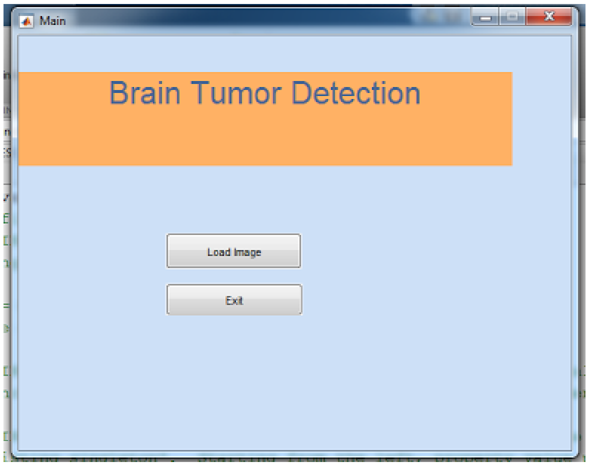

Fig. 3: Loading image page

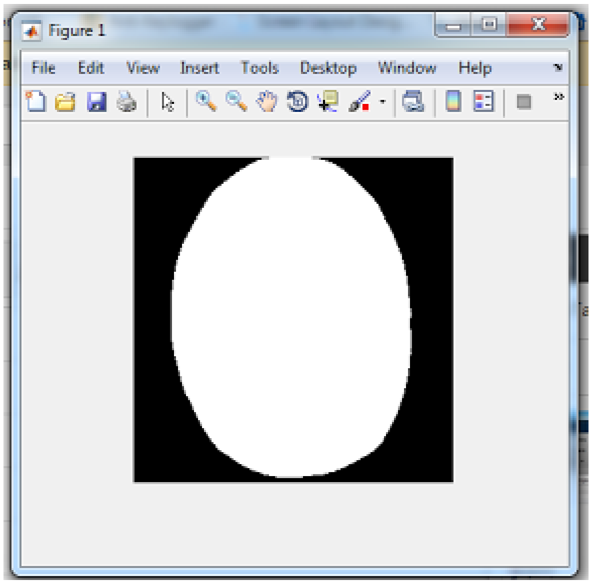

Fig. 4: Initial mask

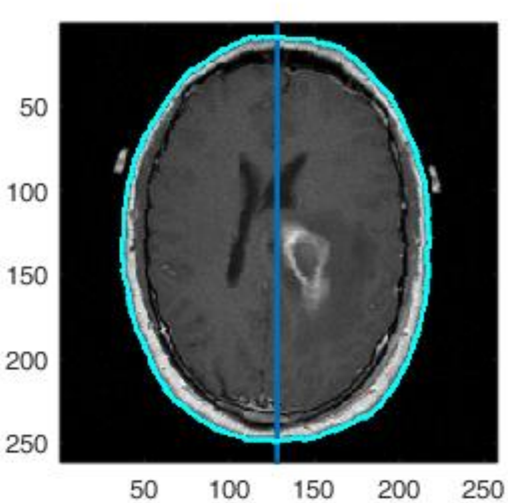

Fig. 5: Segmented Image

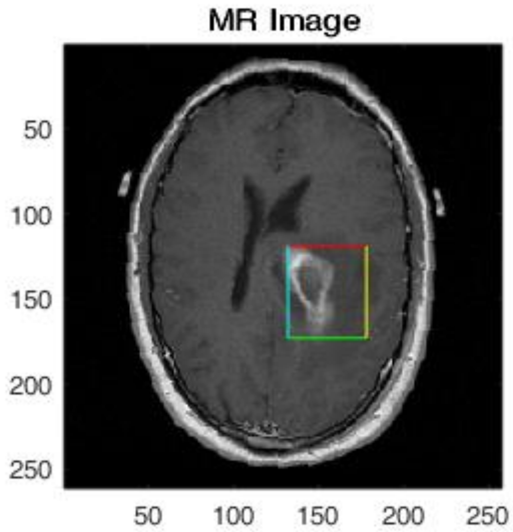

Fig. 6: Detected Tumor

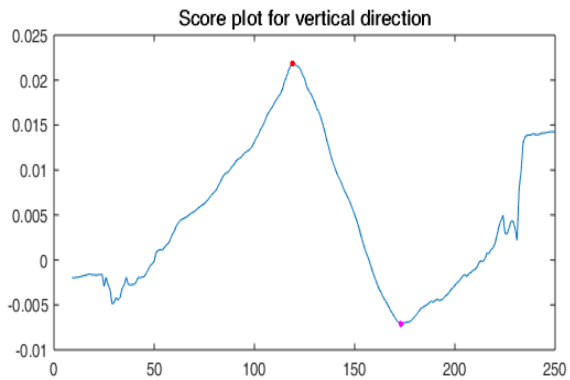

Fig. 7: Range of tumor in vertical direction

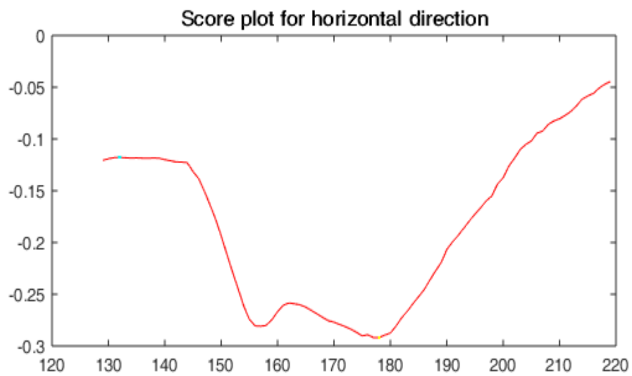

Fig. 8: range of tumor in horizontal direction

A. Abbreviations and Acronyms

- MRI : Magnetic Resonance Image
- ROI : Region of Interest
- BET : Brain Extraction Tool
- BSE : Brain Surface Extractor

IV. CONCLUSION

This system will give nearly accurate location of tumor, along with its stages. The future work can be completely accurate detection of tumor location and stages. In future the system can be used on 3D images in order to enhance accuracy of result.

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