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Brain Tumor Segmentation of Brain MRI Using Watershed Algorithm

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Abstract

One of the life-threatening disease affecting the brain is the brain cancer. Manual segmentation is more time consuming and being susceptible to human bias or mistakes. Detection of the tumor at an early stage becomes necessary in order to save lives. Brain tumor can be detected with the help of MR images. In this paper, we have proposed a method for brain tumor segmentation using deep learning. Here to extract and segment the tumor we used threshold segmentation and watershed segmentation. After the segmentation, morphological operations like image opening, image closing, dilation and erosion were applied to remove the unwanted parts. As a result some useful information in simpler form will be presented in front of the users, especially for the medical staff treating the patient.

Keywords*—Brain Tumor; MRI images; Segmentation; Deep Learning; Morphological Operations.*

I. Introduction

Cancer is one among the major causes of death everywhere. As per survey around 18600 people are supposed to die due to brain and other nervous system cancer in India. Therefore, it can be seen that to fight against cancer is a very big challenge that needs to be faced by patients, doctors, research scientists and clinicians. Brain tumors is on the top of the worst type of cancer list regarding to the critical location, this type of cancer came as tumor takes place in the brain tissue or the surrounding area. Brain tumors are the consequence of abnormal growths and uncontrolled cells division within the brain. They can cause death if they are not detected early and accurately. Some sorts of brain tumor such as Meningioma, Glioma, and Pituitary tumors are more common than the others. Imaging modalities such as Ultrasound imaging, Medical Resonance imaging, CT scan plays a significant role in locating and characterizing brain tumor. Magnetic Resonance Imaging(MRI) is a medical imaging technique,which is extensively used for diagnosis and treatment of brain tumors in clinical practice. MRI scan is employed because it's less harmful and more accurate than CT brain scan. Brain tumor segmentation techniques are a sensitive component in tumor detection. Early prediction of any medical disorder specifically cancer plays a vital role for improving the long term survival rates. But,it can be seen that interpreting the results manually from these medical images is tedious and time consuming job. It can also cause human bias and mistakes. In general medical image segmentation is the method of automaticdetection of boundaries within a 2D or 3D image.

II. Related Work

H.K.Kamal, D.Ruchi, et al. a technique for image enhancing for brain tumor detection has been developed here. Their algorithm was based on digital image segmentation. This algorithm was

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employed to present edge pattern and segment of brain tumor through MRI images. Using this technique they were successful in finding the size and region of brain tumor. They used preprocessing, image enhancement, thresholding and morphological operation.[1]

S.Q.Aqhsa, K.Narayanan, et al. proposed a way for Brain Tumor Detection supporting artificial neural network categorized into Multi-layer perceptron neural network. They used segmentation for feature extraction and invented a way to discriminate normal and abnormal tissues from MRI scanned images. It was helpful to doctor to analyze the stage of cancer and was consuming less time. For this purpose preprocessing, histogram, binarization, thresholding, Morphological operation, GLCM based feature extraction and BPN based classifier were used.[2]

K.S.Angel Viji, J.JayaKumari, et al. an effective modified region growing technique was designed. Comparative analyses were made for the traditional and therefore the modified region growing using both the Feed Forward Neural Network (FFNN) and Radial Basis Function (RBF) neural network. The results were better than normaltechnique. Technique was employed on MRI images for tumor detection. For evaluation of the proposed method the sensitivity, specificity and accuracy values were used.[3]

K.Pankaj, S.Mohinder, et al. used watershed segmentation and morphological operator for detecting tumor from MRI images. Their system includes filtering skullstripping, segmentation and area calculation. For segmentation preprocessing was done. Skull stripping was based on thresholding followed by marker controlled watershed segmentation. They splited the tissues in groups from normal brain image. Finally tumor region was detected with the help of morphological operation and they

determined the location of the tumor on the basis of pixels value of the tumor region. Then tumor area was calculated using frustum model. Proposed method determined exact location of tumor region and extracted tumor accurately from brain MRI image.[4]

G.V.Deipali, D.Vivek, et al. introduced a systematic review of brain disease using deep learning techniques. The investigation and comparative analysis of recent knowledgecorrelated with brain disorder detection using deep learning techniques is considered in this review.[5]

G.Madhupriya, B.Nivetha, et al. the proposed work is predicated on Deep learning technique which may be a deep neural network and probabilistic neural network to detect unwanted masses within the brain. Work is personalized for both high and low level grades.[6]

D.R.Ivan, M.Adrian, et al. reports a new variational model for saliency detection in images and its application to brain tumor segmentation. By incorporating a saliency term to a classical Total Variation based restoration functional, the new model is able to discriminate what is relevant (salient) from the background.[7]

R.Masoomeh, G.Karolien, et al. presented and evaluated an early and late fusion convolutional neural network (CNN) based on Deep Medic architecture to segment brain tumor using different combinations of multi sequence MRI datasets.[8]

K.Venu, P.Natesan, et al. achieved various algorithms used to segment the images automatically, in which the deep learning technique is more efficiently used for large amount of images to find the size and location of cancer. Here it is focused on CNN based deep learning algorithms, as it gives better accuracy.[9]

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V.Kiruthika, C.AmarSingh, et al. focused on improving accuracy and efficiency in medical segmentation process, the proposed tumor segmentation is based on adaptive threshold algorithm. Deeplearning CNN classifier used to compare the test and trained data and produces the result for tumor.[10]

H.Saddam, M.Muhammad, et al. investigated an automated segmentation algorithm for brain tumor using deep convolutional neural networks (DCNN). The algorithm includes preprocessing in which images are normalized and bias field corrected, and post-processing where small false positives are removed using morphological operators.[11]

P.Sergio, P.Adriano, et al. proposed an automatic segmentation method based on convolutional neural network (CNN), exploring small 3x3 kernels as it allows designing a deeper architecture. The use of intensity normalization as a pre-processing step was also done.[12]

III. System Methodology

Brain tumors are the result of abnormal growths and uncontrolled cells division in the brain. They can head towards death if they are not detected early and accurately. The key issue was detection of brain tumor in very early stages in order that proper treatment must be adopted. Based on this information, the foremost suitable therapy, radiation, surgery or chemotherapy can be decided. As a result, it is evident that the chances of survival of a tumor-infected patient can be increased significantly if the tumor is detected accurately as soon as possible. Usually, healthy brain tissue consists of three parts: gray matter, white matter, and cerebrospinal fluid. The segmentation is used to investigate the areas surrounded by a tumor. Magnetic Resonance Image (MRI)has become the standard non-invasive technique for brain tumor diagnosis over the last few decades, due to its improved soft tissue contrast that does not use harmful radiations unlike other methods like CT(Computed Tomography), X-ray, PET (Position Emission Tomography) scans etc.

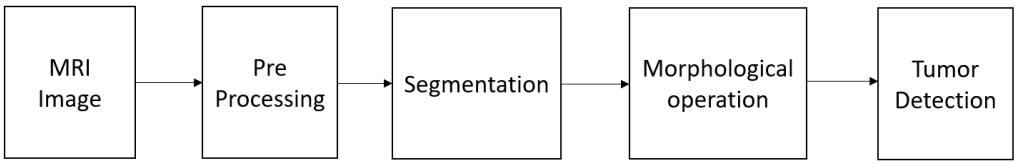

Fig 1. Block diagram of brain tumor segmentation and detection

A. Dataset

This section presents the source of brain MRI image dataset. It includes Brats 2018 and 2013 combination dataset which contain 606 LGG and 1261 HGG. Different modalities of MRI images of the brain were used, including T1-weighted, segmented image, T2-weighted image, T2-weighted FLAIR image.

B. Pre-processing

The primary purpose of preprocessing is to improve the quality of the MR images thus making it suitable for further processing by human or machine vision system. In addition, preprocessing helps to enhance certain parameters of MR images like improving the signal to noise ratio, enhancing the visual appearance of MR image, removal of noise with spatial linear or non-linear filters and undesired parts in the background, RGB to grayscale conversion, reshaping, and preserving its edges.

C. Segmentation

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The segmentation is the most important stage for analyzing image properly since it affects the accuracy of the further steps. Brain tumor segmentation involves the process of separating the tumor tissues (Region of Interest – ROI) from normal brain tissues with the help of MRI images. Here, watershed algorithm is used for the segmentation purpose. Watershed segmentation is a gradient-based segmentation technique. The gradient map of the image is considered as a relief map of the image. It segments the image as a dam. The segmented regions are called catchment basins. Watershed segmentation solves different variety of image segmentation problem. It is considered for the images that have higher intensity value. Watershed transformation has its advantages of being simple but the main drawback is over-segmentation due to presence of many local minima , thus to overcome this problem marker based watershed transformation have been implemented. These are robust and flexible techniques for segmenting objects with closed contours. The internal marker and external marker are defined at the start itself. The boundariesare expressed as ridges between two markers and located, even if not clearly defined. In marker-controlled watershed segmentation to segment the image the external marker is obtained manually by drawing a circle enclosing object of our interest. The internal marker is determined automatically by techniques including Canny edge detection, thresholding and morphological operation. Modify such that it only has minima at theforeground and background marker locations.

D. Morphological Operations

After segmentation, morphological processing is applied to remove the unwanted parts. Morphology deals with study of shapes. It is used for the extraction of the boundary areas of the brain images. Conceptually, morphological operation is rearranging the order of pixel values. It operates on structuring element and input images. The basic morphological operations are dilation, erosion, image opening and image closing.

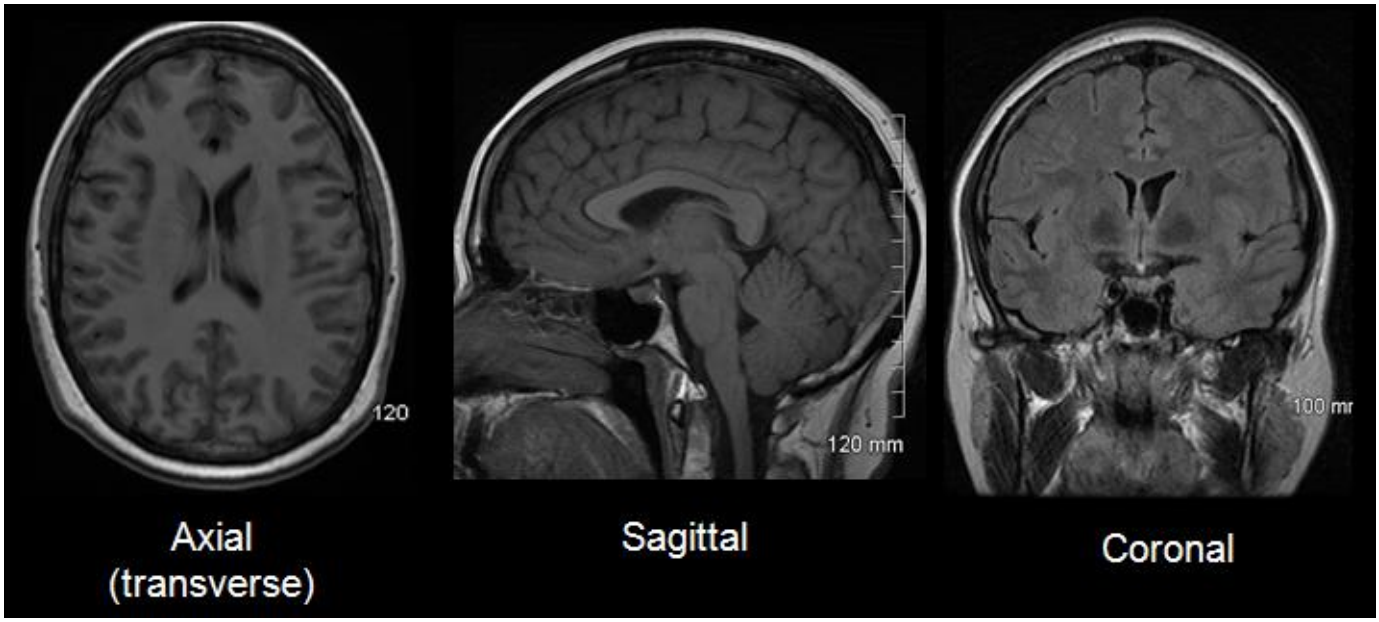

Fig 2. Three views of brain MRI images

Images are captured from different views of the skull; thus the size and position of the tumors varies in different angles. The axial or transverse plane is horizontally oriented dividing the brain into upper and lower sections. The sagittal plane is vertically oriented dividing the brain into left and right sections. And the coronal plane is vertically oriented dividing the brain into front and back sections.

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Thus, the three views of the brain MR images are called as axial, sagittal and coronal. In further process, the segmentation is being applied to these three views of the brain MRI. Thus the tumor is segmented and detected in each of these three views.

IV. Experimentation

Our model is divided into two parts, firstly converting images from 3D/4D to 2D by segregation and then performing segmentation part. In the model we are taking input as MRI brain image which is in nifti files(.nii). The images in nifti files are mostly in 3D or 4D dimension, so they can't be displayed directly just like any 2D images. To view the nifti image we need to convert it from 3D or 4D view to 2D view. For this we are checking whether the image is 4D or 3D image, mostly the images are in 3D format only because 4D is not virtually visible. To convert 3D image to 2D image we perform segregation with the help of mathematical calculations by considering the spacing for aspect ratio, checking the size per slice, taking the middle slice number for reference. The three views of brain are plotted on the window i.e. axial, coronal and sagittal in one frame. We can select any one view according to our choice, convert it into png format image and then give the png format image as input to segmentation unit.

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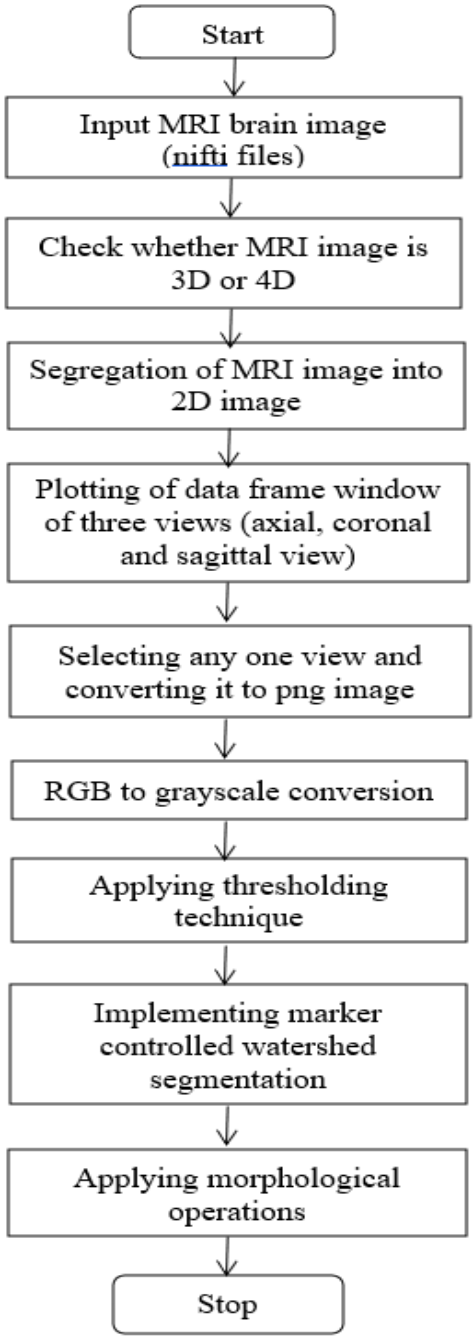

Fig 3. Flow diagram of the proposed system

After that basic pre-processing method of RGB to grayscale conversion is being performed as thresholding requires gray image. In thresholding, we convert an image from grayscale into a binary image, i.e., one that is simply black and white. This is typically done in order to separate foreground pixels from background pixels. In segmentation process, the brain image obtained from the thresholding step is segmented using marker controlled watershed segmentation. Using the gradient image, the watershed transform is done. Next, the segmented image is divided into normal brain region and tumor region according to the intensity values of the original image. To enhance the image and remove unwanted part we are applying morphological operations like opening and closing. Thus, the tumor is detected and segmented in the MRI images.

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V. Results and Discussions

Next figure shows the resultant image as an output i.e. data frame, three view images, thresholding, water segmented images. As tumor in MRI image have an intensity more than that's of its background so it becomes easy to locate and extract the tumor from image

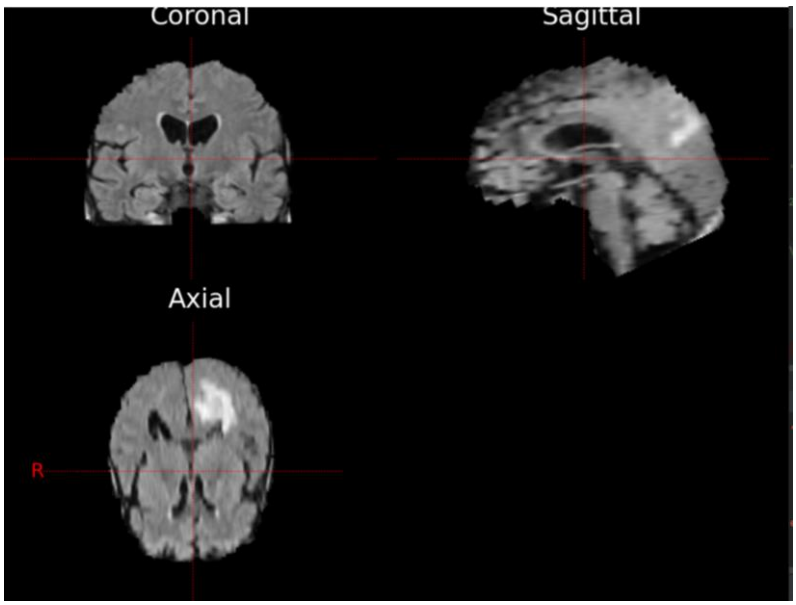

Fig 4. BRATS 3D MRI image converted into 2D with all views

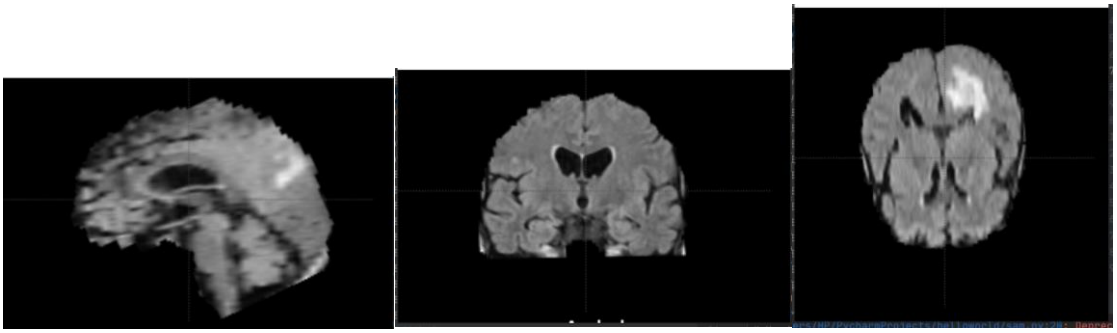

Fig 5. Three views of Brain Images

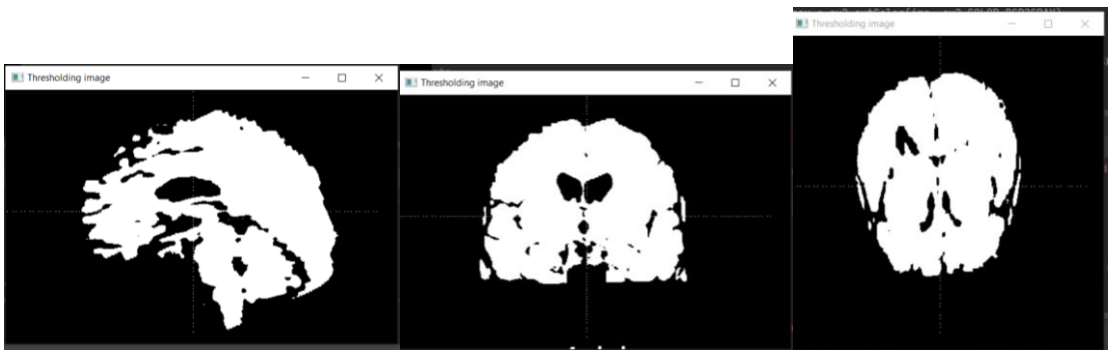

Fig 6. Thresholding images of three views

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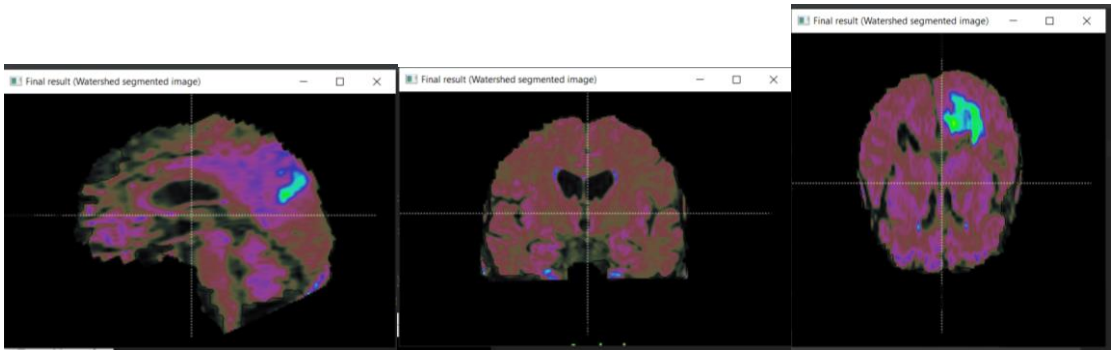

Fig 7. Watershed segmented images of three views

This section presents the results of our proposed image segmentation technique, which are obtained by using real brain MRI images. From the result we can predict that the green colour indicates the main tumor area where as the blue colour represents the subsequent brain edema in the nearby tissues. It can be seen that the sagittal view does not contains details of other organs and tumor is more prominent here than the other images. Also it was observed that as compared to the other images, the axial view was consisting of fewer details.

VI. Conclusion and Future Scope

The diagnosis of brain diseases requires accurate diagnosis without any deviation. Any misdiagnosis will cause irreparable losses. The incidence of brain tumour has been high, and the number of patients has increased year by year. The workload of medical personnel in this field has also increased to a certain extent. An accurate and efficient method of brain tumour image segmentation must be urgently suggested as soon as possible, which has solved the increasing demand. Here, in model sagittal view has more accuracy than axial and coronal view as it prominently highlight the tumor area rather than other organs. Based on this background, themodel focused to improve the segmentation accuracy and also to achieve automatic segmentation without manual intervention.

In the future work, method may be implemented as a simple and useful tool for doctors in segmenting the brain tumor from MRI images. Also different classifiers can be used to increase the accuracy combining more efficient segmentation techniques. Moreover an app-based user interface can be build in hospitals which allows doctors to easily determine the impact of tumor and suggest treatment accordingly.

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