Detection of Brain Tumor from MRI Images: A Review

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Abstract: Brain Tumor, the outcome of uncontrolled divison of the cells has resulted in number of the deaths. MRI technique is generally used to detect the presence of any abnormality in brain. In this paper, Neural Network algorithm is used for the detection of Brain Tumor from the MRI images and a GUI is developed, which is used to detect the location and area of the tumor in the brain.

Keywords: Brain Tumor; MRI; MATLAB; Feature Extraction; Neural Network.

Introduction

Brain Tumor is one of the most serious diseases that has resulted in the number of deaths. According to American Society of Clinical Oncology (ANCO), in 2015, an estimated 22,850 adults (12,900 men and 9,950 women) in the United States will be diagnosed with primary cancerous tumors of the brain and spinal cord. It is estimated that 15,320 adults (8,940 men and 6,380 women) will die from this disease this year. About 4,300 children and teens will be diagnosed with a brain or central nervous system tumor this year [1]. It has been caused due to abnormal and uncontrolled divison of the cells. Normally, the cells in the body die with age and are replaced by new cells. But, with cancer and other tumors, this cycle is disrupted because the tumor cells grow, even though the body does not need them. As the process goes on, tumor continues to grow more and more are added to mass. When these abnormal cells are created in brain, it is called brain tumor. A tumor can cause damage by increasing pressure in the brain, shifting the brain or pushing against the skull, and invading and damaging nerves and healthy brain tissue. Basically, brain tumor is divided into Primary Brain Tumor and Secondary Brain Tumor.

Primary Brain Tumor originate in the brain itself. They may be localized or extended. They are further divided into Benign and Malignant Tumor. Benign brain tumors are noncancerous. They have clearly defined borders and usually are not deeply rooted in brain tissues, thus, making it easier to surgically remove them. But, even after they have been removed, they can still come back, although benign tumors are less likely to recur than malignant ones. Malignant Tumors originate in the brain and grow faster than benign tumors, and aggressively invade surrounding tissue. Brain cancer rarely spreads to otherorgans, but it will spread to other parts of the brain and central nervous system. Secondary brain tumor is one that begins as cancer in another part of the body. Some of the cancer cells may be carried to the brain by the blood, or may spread from adjacent tissue. There has been an increase in secondary tumors as people are surviving primary cancers for longer periods of time [2-3].

The paper is organized as follows: Section 2 involves preprocessing and enhancement. In section 3, the image segmentation techniques are explained. In section 4, feature extraction is applied to extract the features. In section 5, classification is done using two neural algorithms. In section 6, the proposed algorithm for brain tumor detection and location of tumor region is discussed. In section 7, the results are presented.

Preprocessing

Preprocessing involves image resizing, conversion to gray level, filtering etc. The input image is converted to a gray level image because it is difficult to detect tumor using color images. The image is resized, it expands or contracts the gray levels, if they are less than or more than the specified size. The high frequency components are removed by employing the filtering technique. The original MRI as well as preprocessed image is shown in Fig. 1 and Fig. 2.

Image Segmentation

Image segmentation is one of the most important steps for the analysis of the image. The various segmentation techniques involved are sobel edge detection, adaptive thresholding, prewitt edge detection, canny edge detection etc. From these, adaptive thresholding and canny edge detection technique has been used for the image segmentation of the brain. These techniques provide better details of the brain MRI so as to identify the tumor portion in the brain.

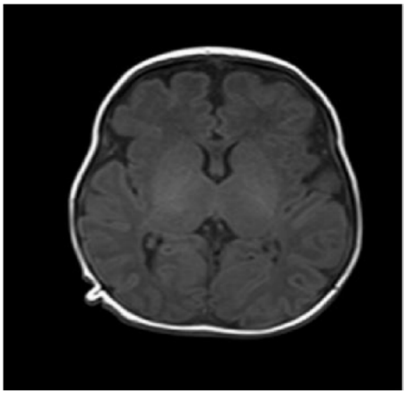

Fig.1 MRI image of Normal Brain

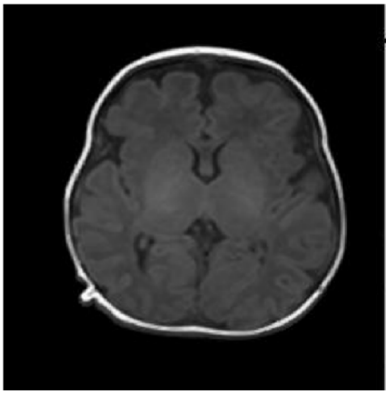

Fig. 2 MRI image after Preprocessing

The adaptive thresholding technique [5] is applied to the MRI image shown in Fig. 2. In this, a parameter θ is defined for the brightness threshold, which is specified by the user. It is used for converting the image into the binary image. The adaptive thresholding technique when applied to MRI image gives the binary image as shown in Fig. 3.

Fig. 3 Image segmentation using Adaptive Thresholding

Canny edge detection technique is used to find the points at which luminous intensity of image changes sharply. The canny edge detection technique involves the following steps:

- Smooth the input image with the Gaussian filter to reduce the noise.
- Then, compute the gradient magnitude and angle images. An edge point is also defined that is point whose strength is locally maximum in direction of the gradient.
- Apply nonmaxima suppression to gradient magnitude image. Edge points give rise to the ridges in the gradient magnitude image. It tracks along top of the ridges and sets to zero all pixels that are not actually on the ridge top, so as to give a thin line in the output, known as nonmaximal suppression.

- Finally, algorithm performs the edge linking by incorporating the weak pixels that are connected to the strong pixels [6].

The canny edge detection when applied to the MRI image is shown in Fig. 4.

Fig. 4 Image segmentation using Canny Edge Detection

Feature Extraction

It is used to extract the features of the image. It is used to minimize the complexity and processing time for the analysis of the image. It can be done using LOG-Lindeberg algorithm, Harris- Laplace and Harris algorithm. But, Harris algorithm is used for the purpose of feature extraction. The steps involved in harris algorithm are:

1) First, find the luminance value.
2) Then, set the derivative masks and find the derivative image.
3) Find the derivative image.
4) Find the sum of autocorrelation matrix.
5) Find the interest point response.
6) Then, set the threshold as a one percent of the maximum value.
7) Find the local maxima greater than threshold.
8) Finally, build the interest points [3].

The feature extraction using harris algorithm of MRI image is shown in Fig. 5.

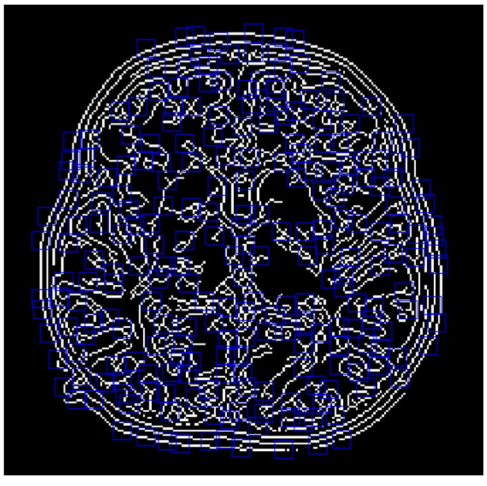

Fig. 5 Feature extraction using Harris Algorithm

Neural Network Classification

The neural network algorithms are used for the classification of the MRI images. It consists of three layers that are input, hidden and output layer. The training is done using the different input features. After training, the testing of it is done. Two neural network algorithms are involved of which one classifies MRI images into healthy brain and brain with tumor. Then, if tumor exists, it is then classified into the benign and malignant tumor.

Implementation of Algorithm

GUI is constructed for the detection of location and classification of brain tumor. The algorithm involvespreprocessing, image segmentation, feature extraction, classification and ROI extraction, determining location and area of tumor. In preprocessing, the input image is changed to 256x256. It means that gray levels are expanded or contracted in image from 0 to 255. The image is filtered using median filter. Then, image segmentation is done using adaptive thresholding and canny edge detection. After segmentation, features are extracted using Harris algorithm. Then Neural Network algorithm is used for the classification. It is trained using Scaled Conjugate Gradient. The performance is measured on the basis of Mean Squared Error (MSE). It is then tested for classification of MRI images into healthy brain and brain with tumor. In this algorithm, the canny edge detection is used for the image segmentation. If the tumor exists, then, second neural network algorithm is applied to classify whether it is benign or a malignant tumor. For this, the image segmentation is done using adaptive threshold technique. Finally, ROI is extracted to define the location of the tumor. If tumor exists, then white portion appears whereas for a healthy brain, only the brain boundary appears. The calculation of the area of the tumor is done. If it is healthy brain, then it will not show any calculation. The location of lobe in which tumor is present is determined using ROI.

Results

The programming for the project is done in MATLAB and the user friendly GUI is constructed to perform all these functions. The database for the images is obtained from the internet. Total 28 MRI images of brain are available, out of which 7 are of normal brain while the other 21 are of benign and malignant tumors. 18 images are used for training the neural network and the rest 10 images are used for testing of the neural network. The images of the constructed GUI are shown in Fig. 6, 7, 8. The Table 1 and 2 show the recognition rates of neural network algorithm.

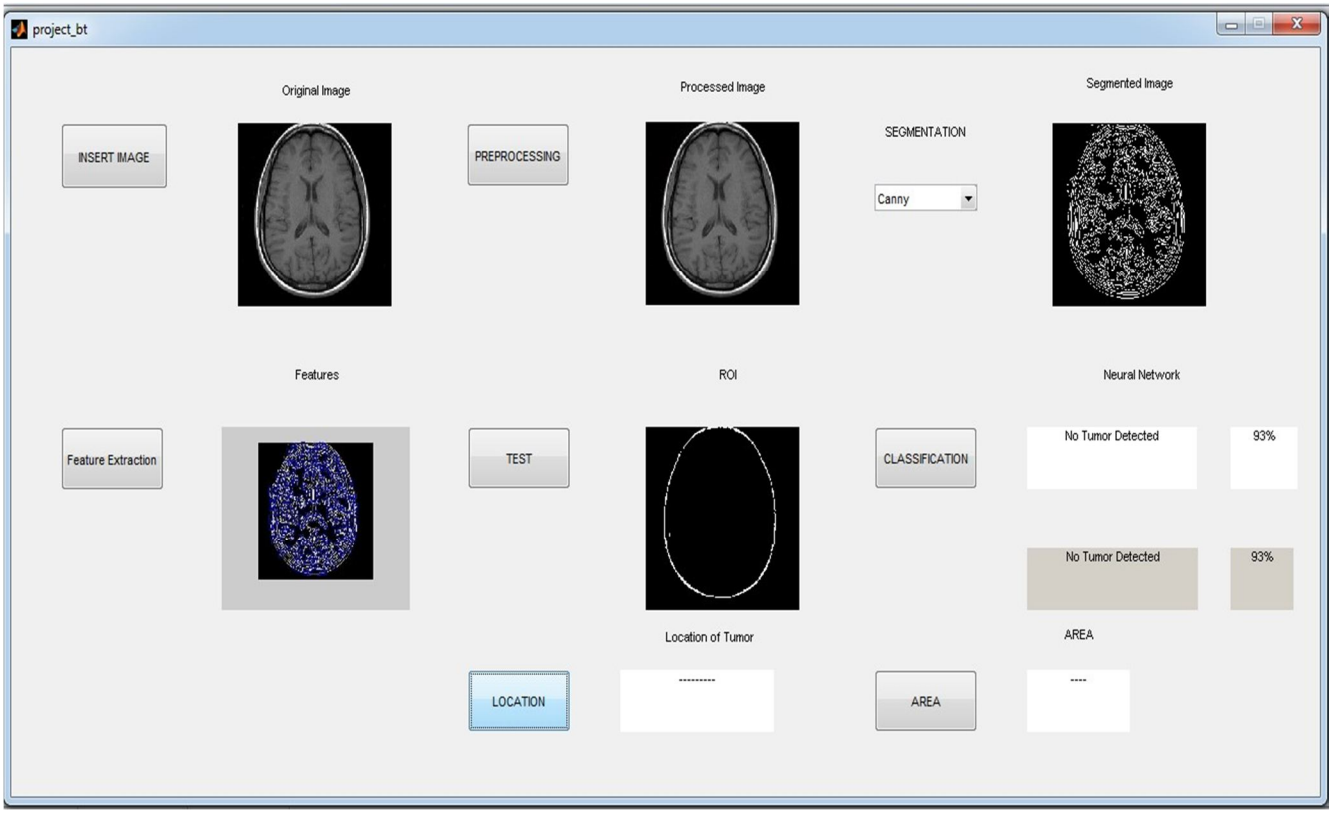

Fig. 6 GUI that detects the Normal Brain

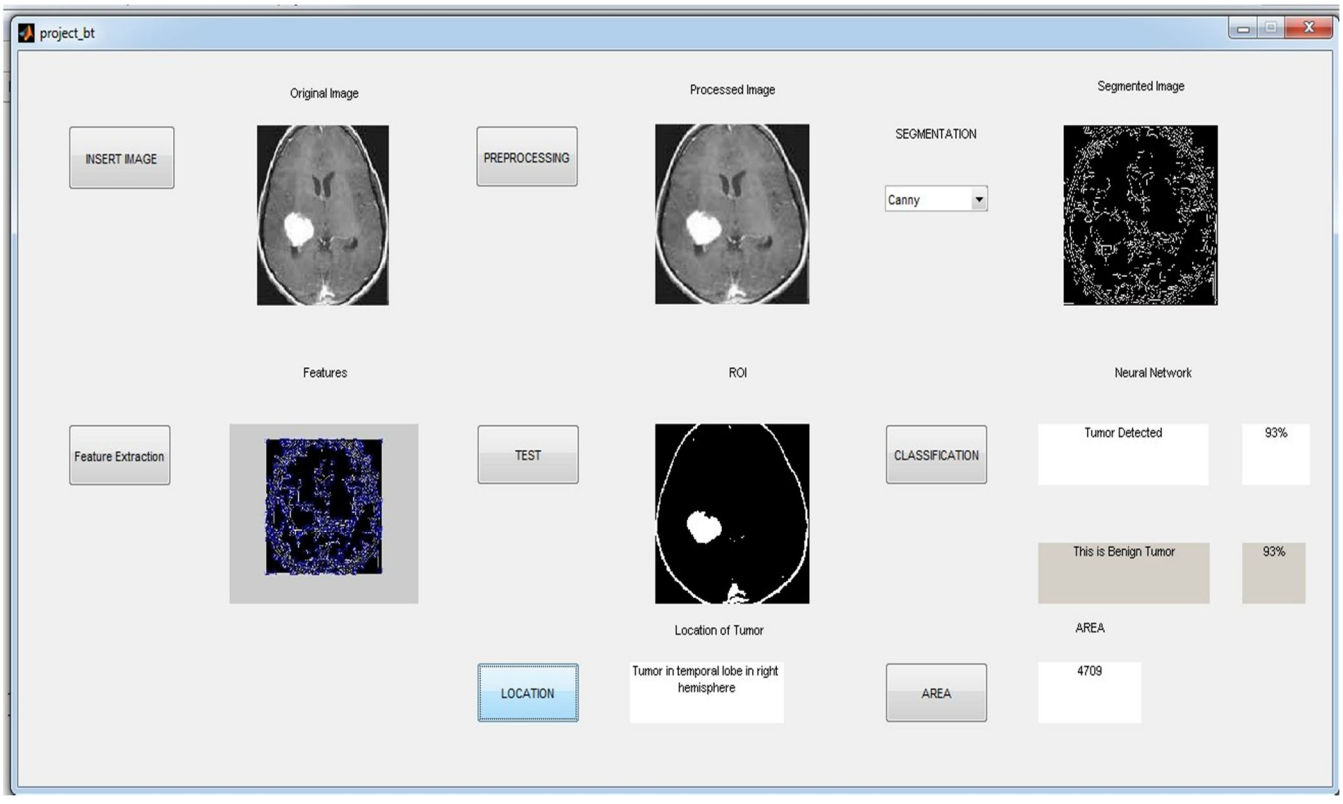

Fig. 7 GUI that detects the Benign Tumor

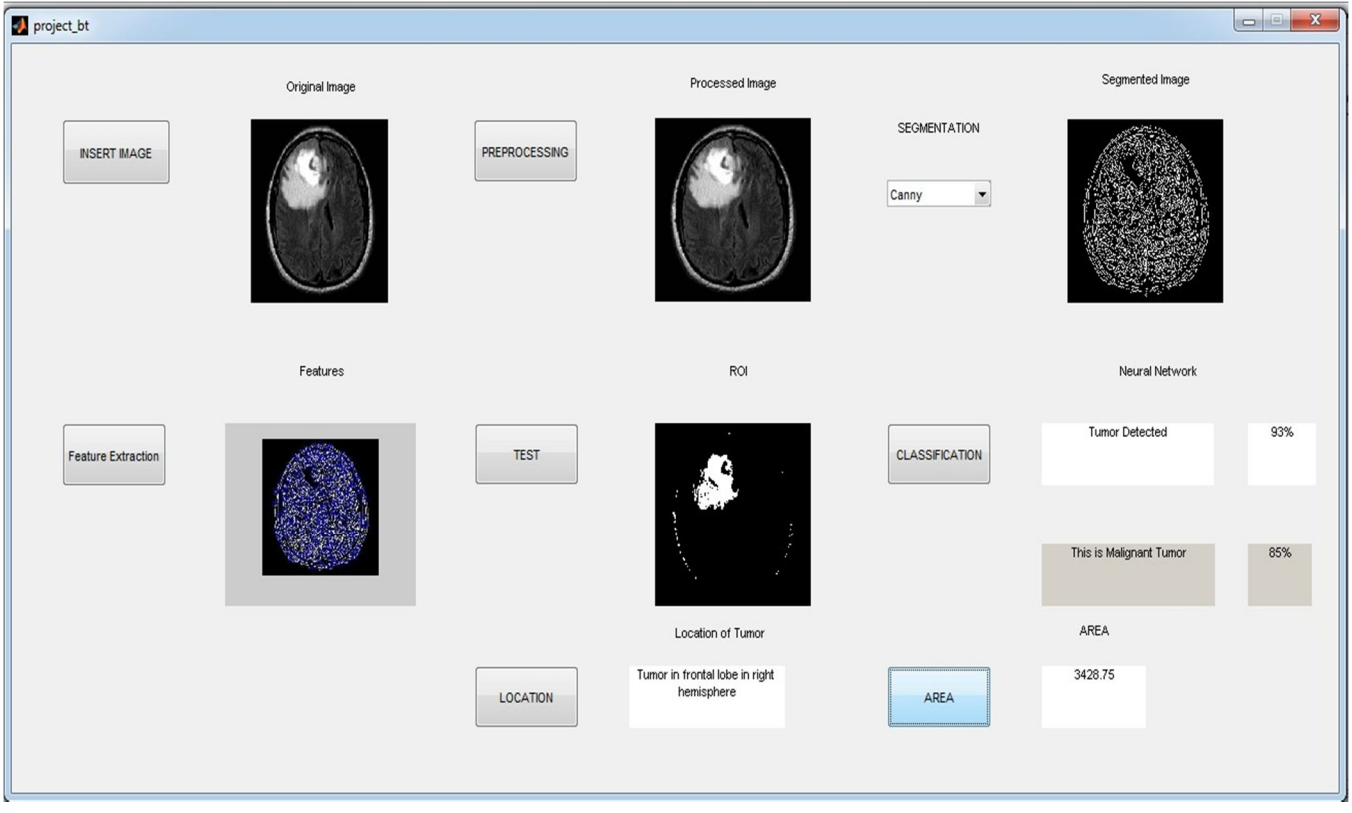

Fig. 8 GUI that detects the Malignant Tumor

Table 1. Recognition rate of neural network algorithm 1

Parameters	Neural Network Algorithm 1	
	Normal Brain	Brain with Tumor
Detection as Healthy Brain	100%	0%
Detection as Brain with Tumor	0%	100%

Table 2. Recognition rate of neural network algorithm 2

Parameters	Neural Network Algorithm 2	
	Benign Tumor	Malignant Tumor
Detection as Benign Tumor	75%	20%
Detection as Malignant Tumor	25%	80%

Conclusion

The user friendly GUI is constructed for the detection and classification of brain tumor. It determines if the brain is healthy or having tumor. If tumor exists, it then classifies it into benign and malignant tumor and calculates the area of the tumor. It also defines the location of the tumor that is in which lobe tumor is present. In future, more accuracy can be achieved by increasing the size of database. Moreover, these algorithms can be implemented on other type of cancers.

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