International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 04 | Apr-2018 www.irjet.net p-ISSN: 2395-0072

Automatic Brain Tumor Tissue Detection in T-1 Weighted MR Images

Hasni[1], Anu[2]

[1,2] *Student, Dept.of Computer science and Engineering, CCET-Valanchery, Kerala, India*

Abstract - *Brain tumor is one of the most dangerous disease. Therefore brain tumor detection should be fast and accurate. The automatic brain tumor tissue detection allows to localize the mass of tumor cells in the Magnetic Resonance Images (MRI). Several automatic methods are proposed for brain tumor tissue detection. Here a four-step procedure is proposed which include Segmentation, Morphological operations, Feature extraction and Classification method. There are training and testing sections. Brain extraction is used as the pre-processing step in order to remove the skull, and median filter will remove the noise present in the MRI. The k-means clustering method segment the MRI image into specific number of clusters. The morphological operations are used to select and segment the tumor section alone from the MRI image. GLCM (Gray Level Co - occurrence Matrix) will extract the features from the MRI image. The detected brain tumor is classified through KNN (K - Nearest Neighbours algorithm) classification method.*

Key Words: Brain Tumor Detection, Classification, Kd-tree Decomposition, Segmentation, Magnetic Resonance Imaging (MRI).

1. INTRODUCTION

The most complex part of the human body is the brain, which is also the central organ of human nervous system. There are two types of brain tumors; benign and malignant. Benign tumors are non-cancerous and malignant tumors are cancerous. Malignant are more harmful as compared to benign tumors. Malignant tumors are further divided into two types; primary and secondary tumor. Primary tumor develops in the brain itself, spreading rapidly into the other tissue of the brain, thus worsening the patient condition. It is the rarest type of brain tumor. Secondary tumor occurs as a result of a cancerous tumor that has developed in another part of the human body, like lung cancer or breast cancer. This is the most common type of brain tumor. it is also known as metastatic brain tumor. The detection of the brain tumor becomes key challenging because of the compound structure of the brain. The various shape, size, location and appearance of the tumor in brain makes the daignosis more difficult. Detection of the brain tumor is complicated in the earlier stage as it cannot detect the exact size of the tumor. However, the brain tumor may be cured through the correct treatment, once it is identified . Magnetic Resonance Imaging (MRI) is a medical imaging technique used in radiology and it is used to take the anatomical and physiological structure of the human body. It also helps in analysing the brain tissues. Early detection and proper treatment helps in saving the patients life. Chemotherapy, radiotherapy and surgery used to treat the brain tumor. Due to the increase in medical dataflow, the accurate detection of tumor in the MRI slices becomes a fastidious task to perform. This method automatically detect the abnormal tissue in pre-operative images. The automatic brain tumor tissue detection based on hierarchical centroid shape descriptor in T1-weighted MRI uses axial view of the brain image (2D) from MRI scan. A patient is subjected to different diagnostic methods to determine the cause of the symptoms mentioned by him [1]. The diagnostic methods like performing a biopsy and performing imaging, like taking a MRI or CT scan of the brain will be done. In biopsy, pathologists take a specimen of the brain tissue under consideration for checking the presence of tumor. A pathologist looks at the tissue cells under a microscope to check for the presence of abnormality. The biopsy will show the presence of tumor and its pathology. When doctors go for surgery, they must know the tumor extent and the exact location of tumor in the brain, which can be found by taking MRI scan of the patient. MRI doesn't involve the use of harmful radiations when compared to CT scan. Traditional method in hospitals is to segment the medical image under consideration manually. This depends on how well the physician can perceive the image under consideration to get the required region, which is difficult because of minute variations and resemblance between the original and affected biological part in the image. The shortage of radiologists and the large volume of MRI to be analysed make these readings labour intensive and also cost expensive. It also depends on the expertise of the technician examining the images. Estimates also indicate that between 10 and 30 percentage of tumors are missed by the radiologists during the routine screening. Hence the automatic detection and segmentation of brain tumor plays an important role in medicine because it leads to critical decisions. Recently several works were focused on this problem which is not entirely solved.

The automatic detection of the tumor in T1-weighted Magnetic Resonance Images is a robust method. For achieving this goal, the k-means clustering algorithm was associated with morphological operations. A preprocessing step is performed for removing the skull and extracting only the brain.

The most common MRI sequences are T1-weighted and T2-weighted scans. T1-weighted MR images are produced by using short TE (Time to Echo) and RT (Repetition Time) times[2]. The contrast and brightness of the images are predominately determined by T1 properties of tissue. Conversely, T2-weighted MR images are produced by using longer TE and RT times. In this the contrast and brightness are predominately determined by the T2 properties of tissue. Flair is the third commonly used MRI sequence.

2. LITERATURE SURVEY

S. Ghanavati, J. Li, T. Liu, P. Babyn and G. Lampropoulos uses three steps to detect the brain tumor from MRI. The steps are, Data Pre-processing, Feature Extraction, Classification. Each MRI is first preprocessed here to minimize the intensity bias and to remove the non brain tissues. The image registration method is also used in this preprocessing step. In second step, four types of features are extracted from the preprocessed images. AdaBoost classifier is used for the feature selection and fusion. In Data Pre-processing The intensity inhomogeneity of the MR images are corrected here by using an automatic method (Non-parametric Non-uniform intensity Normalization. Brain Extraction Tool (BET) is used to remove the non brain tissues such as skull and eye automatically from each images. Based on mutual information the different MRI modalities of each subject are co-registered using a multi-modality multi-resolution registration method. At last, the histogram matching is used to normalize the image. Each of the training and test images go through the preprocessing step. In Feature Extraction The feature extraction step will also be performed on the images in both training and test part of the system. Intensity, symmetry, shape deformation and texture are the four features that are extracted from each MRI. In Classification The discriminating power of the features leads the performance of the tumor detection method. AdaBoost is used as the classifier, which will select and combine the most discriminative feature during the training process. The tumor area is segmented from the MRI based on the AdaBoost classifier.

Eyup Emre Ulku and Ali Yilmaz Camurcu Propose an approach designed to increase the diagnostic accuracy of the automatic brain tumor detection system. Preprocessing, segmentation, feature extraction and classification are the main stages used in the CAD system. The histogram equalization is used in the preprocessing stage. Hence this system is called as Morphologic Brain Tumor Detection System with Histogram Equalization [4]. Histogram is a graph and it shows the number of colour values in the image. The histogram equalization will resolve the irregular distribution of the pixel in the image and the image become more distinct. The MR images become more clear by applying histogram equalization hence it leads to more successful segmentation. In Segmentation The Region Of Interest(ROI) is segmented in this process. The morphological image processing techniques such as erosion and dilation are used to segment the tumor area from the MRI. After segmenting the ROI, the features of segmented tumor is extracted through the feature extraction process. The gray level, luster, colour and texture features are extracted from the ROI. In Classification The features extracted from the ROI is recorded into an Excel file during feature extraction process. The Excel file is used as a program entry in the RapidMiner program. RapidMiner program is used in this approach for the classification purpose. The ROI is classified with six different classification algorithm in the RapidMiner program. K nearest neighbour and Particle Swarm Optimization support vector machines (SVM)provide most successful result in the tumor classification.

Manoj Diwakar, Pawan Kumar Patel and Kunal Gupta Proposes an approach is based on cellular automata[5]. Cellular automata is the most researched area among researchers. Basic component of cellular automata is cell and all calculations or operations are processed based on the state of a cell. The cell can store one state at a time. The Cellular automata changes their state continuously based on rules applied. The rules depends on the neighbours of the cell. The rules specifies the next state of a cell based on the old state of the cell and its neighbour cells. 1st step is Conversion to binary image, approach will work based on the binary image. The gray level image is converted in to binary image using im2bw toolbox function. Hence it will convert the entire range of pixel intensities in the range [0, 1]. Next step Setting Cellular Automata Map Here defining a rule. For example, a cell will die, born or keep its state depending on certain number of neighbours of the cell. Following is the rule for this algorithm[5].Loneliness - If a cell has less than 2 neighbours, it dies. Over population - If a cell has more than 8 neighbours, it dies. Happiness - If a cell has either 3, 4, 6 or 7 alive neighbours, it goes on living. Reproduction - If a cell has exactly 5 neighbours, it comes alive. Count number of neighbours is the 3rd step All cells have black or white colour in the binary image and the black cells represents the alive cells and the white cells represents the dead cells. The number of neighbours of the cell is calculated in this step by using the neighbourhood matrix. The neighbourhood matrix is calculated by considering 3 X 3 matrix and then sum the values in the 3 X 3 matrix. The last Apply Edge Detection Rules The cells having 3, 4, 5, 6 and 7 neighbours will be alive in next generation after applying the rule and other cells will be dead in the next generation. Hence the edge gets detected.

S. Charutha and M. Jayashree proposes an approach[6] combines the two image processing techniques such as texture based region growing and cellular automata based edge detection. The benefits of each individual techniques are used in this approach to detect the brain tumor. In Image Acquisition The MRI data sets are acquired through this step. The .jpg format images are used here. In Pre-Processing The acquired images contain noises due to the movement of patient during MRI scanning. The MR images becomes more clear by removing the noises. preprocessing steps used in this approach are Gray-level conversion: The .jpg format MR images are converted from RGB model to gray-level image. Resizing of image: The gray level images are resized into 200 X 200 size. Median filtering: The noise is removed by using median filter and it will reduce the edge blurring effects also. High-pass filtering: High pass filter is applied on the median filtered image. Then it will enhance by adding the resultant image with the resized image. Modified Texture Based Region Growing This is the first level of segmentation used in this approach. The modified texture based region growing is based on texture and intensity. The texture filter is used to

get the texture of the image. Threshold value for texture and intensity are selected. The neighbouring pixels have to satisfy two predefined constraints after selecting the seed point. The predefined constraints are, Texture constraint and Intensity constraint. Texture constraint: The seed pixel and neighbouring pixel texture values difference is less than or equal to the texture threshold. Intensity constraint: The seed pixel and neighbouring pixel intensity values difference is less than or equal to the intensity threshold. The pixels are grown only if both the intensity constraint and texture constraint are satisfied. Cellular Automata Based Edge Detection is the second level of segmentation. The cellular automata works on the binary image. Hence the preprocessed image is converted into binary image. The rule number 124 from the 2D cellular automata based on more neighbourhood model is used [6]. This methods is based on the cell and its states. The rule states that each cell undergoes through four situations such as loneliness, over population, happiness and reproduction. The black represent live cells and white represent dead cells. Then for each pixels number of neighbours are calculated in the image. By applying the rule number 124, the cells are alive in next generation if that have 3, 4, 5, 6 and 7 neighbours and other cells will be dead in the next generation. Modified Texture Based Region Growing + Cellular Automata Edge Detection is the last step. The main advantage of modified texture based region growing is that inhomogeneity of tumor will not affect its efficiency. The selection of threshold value will affect the performance of modified texture based region growing method. The exact or clear boundaries or edges of brain tumor are detected through cellular automata. It will not be detected if the intensity difference between the normal and tumor cell is less. Hence by taking the advantages of both techniques, they are incorporated and the accurate size and location of the brain tumor will be detected.

2. PROPOSED SYSTEM

An efficient method which can detect and classify brain tumor from MRI images is introduced. This method contain training and testing sections.

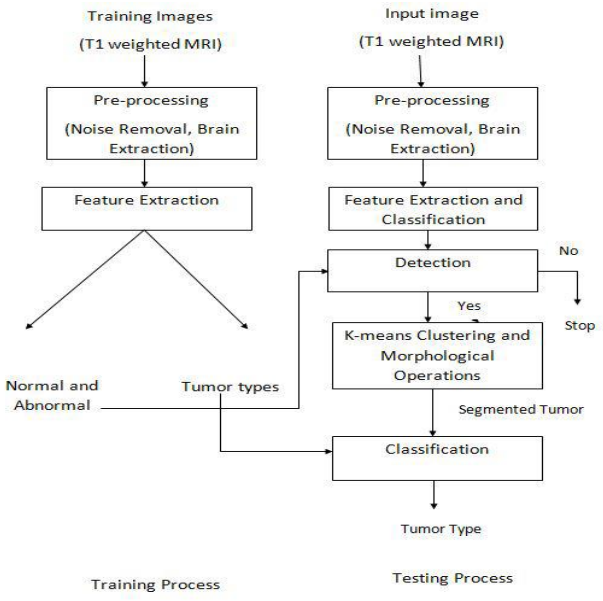

Figure 1 Overview of the proposed method

The proposed Automatic Brain Tumor Tissue Detection in T-1 weighted MR images method follows training and testing sections. The training section has pre-processing and feature extraction. Testing section consist of pre - processing, feature extraction, detection, segmentation and classification. Number of MRI images trained into normal, abnormal, benign and malignant through the training section. The brain tumor detected and classified in testing section based on the trained features and it is used in classification method. The architecture of the proposed method is shown in figure 1.

2.1 Pre – Processing

Preprocessing is done to facilitate the process which removes the portions in the image that are not needed for the brain tumor detection. Hence the skull of brain removed from the MRI image by using thresholding technique and morphological operations. There may be noise in the brain MRI image that may lead to decrease in the accuracy of the process. After skull stripping process, the noise in the MRI image is then removed by using median filter. The median filter can also preserve edges while removing the noise present in the image. Brain extraction and noise removal method used as pre - processing steps in both training and testing sections.

2.2 Feature Extraction

Features are the characteristics of the objects of interest. Feature extraction is done for extracting the important information in the image. The feature of the brain MRI images will be extracted by using Gray-Level Co-Occurrence Matrix (GLCM) [9]. The classifier get input characteristics from extracted features. The extracted features from the MRI database is trained in training section. The features from the input MRI image is also extracted for testing. The features

such as texture, intensity, contrast, homogeneity, color, shape and entropy will be extracted from each brain MRI image.

2.3 Detection

The input brain MRI image is checked in this step for detection of tumor. The KNN (k-nearest neighbour) classifier is used for detection. KNN method will compare the features extracted from training section and testing section. The classifier will decide whether the brain MRI contains tumor or not based on the trained features. If the MRI contains tumor, then it will move to the further processing. The process will stopped if there is no tumor region.

2.4 Segmentation

This process is used for extract the tumor region alone from the MRI image. This section includes two steps such as k-means clustering method and morphological operations. K-means clustering method will segment the MRI image into four clusters where each clusters have a centroid. The different result for each iteration is avoided by using 'replicates' option. Hence this will automatically run the algorithm multiple times and output the best result.

The tumor is the brightest class in the T1 weighted MRI. Morphological operations can used to segment the tumor region. The cluster with maximum index value is found and largest blob is extracted from the obtained image. After these operations the tumor region is separated from the brain MRI image.

2.5 Classification

The tumor classification into types can decide the type of treatment plans and this will help surgeon . The KNN (k-nearest neighbour) classifier also used for classification purpose. The trained features of tumor types are used by KNN classifier. The classifier will compare the features extracted from input MRI image in testing section with the trained features. Then the KNN will classify the tumor type. Following is the algorithm for KNN method.

1. For each training sample $< x, f(x) >$, add the sample to the list of training samples.
2. Given a query instance x_q to be satisfied.
3. Let x_1, x_2, x_k denote the k instances from training samples that are nearest to x_q.
4. Return the class that represents the maximum of the k instances.

3. CONCLUSIONS

In this approach, a new strategy to detect brain tumor tissue is introduced. This method consists of training section and testing section. The brain extraction is done by using thresholding technique and median filter remove the noise present in the MRI image. Training is performed on the brain MRI database and it will output the trained features of normal, abnormal and types of tumor brain MRI images. The feature extraction is done by using GLCM method. Tumor detection done in the testing section is based on the trained classifiers. The highlighted structures like tumors are detected in the high intensity cluster by k-means clustering method. The morphological operations segment the tumor section alone from the brain MRI image. Segmented tumors are classified into benign or malignant. Detection and classification is done by using KNN classifier. The experimental result shows that the proposed approach obtained 93% accuracy.

In future the work can extended to use more database for training and testing purpose. k- means method also can replaced by a better segmentation method.

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