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MRI Brain image Segmentation and Classification: A Review

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Abstract – Brain tumor detection and classification is one of the most active research areas in medical image processing field. The brain tumor segmentation of the MR image is time consuming manual task. Segmentation is a difficult task because tumors in MRI have different size, shape, location and intensities.
In this paper, we described various brain tumor segmentation techniques. Another challenging task is to classify the image into different classes such as malignant- benign, glioma-meningioma etc. In this paper we present various segmentation and classification techniques.

Key Words: *Image processing, MRI, Soft computing, Segmentation, Feature extraction.*

1. INTRODUCTION

Brain is the vital part of the human body. Brain tumor is a very serious disease occurs because of uncontrolled growth of cells in the brain. There are different type of tumors occur in the brain, such as malignant and benign. Benign is a non cancerous tumor, grow slow while malignant tumor is a cancerous tumor, grow fast and causes serious harm to the brain causes death. Brain cancer again divides into glioma and meningioma.

Brain cancer is the leading cause of the death from cancer. There are two main types of cancer, according to their stage, i.e. primary and secondary. Primary cancer found rarely. It is mainly found in brain tissue and spread in spinal cord, but not another part of the body. Another type is secondary cancer which originates in another part of the body and spread into the brain. Such a cancer is known as metastatic cancer.

Risks of the brain cancer are more who have a family history of brain cancer and people who had radiation therapy of the head. The brain cancer is curable when it is diagnosed at early stages and treated early.

The Neurologist is the specialist who diagnosed the brain cancer. There are different techniques to diagnose the brain cancer, but the popular one is the brain magnetic resonance imaging (MRI) or CT scans.

2. GENERALIZED BRAIN TUMOR DETECTION SYSTEM

The generalized structure of any brain tumor detection system using medical images is as shown in figure 1. The system mainly consists of six sections those are listed as below,

1. Image Acquisition
2. Image Pre-processing
3. Image Segmentation
4. Region of Interest
5. Feature Extraction
6. Classification

2.1 Image Acquisition

Acquisition of the image is the first step of image processing. The MRI images having low contrast and small volume nodules. Brain MRI images can be acquired from publicly available databases. The MRI images can be collected from the radiologist.

2. 2 Image Pre-processing

The aim of the preprocessing is to improve the image data and minimize the effect of noise. The MRI images containing the least amount of noise, but to get more accuracy of the system, the small noise have to removed. Hence need preprocessing step.
The preprocessing of the images goes through following two steps.

1. Image Smoothing
2. Image Enhancement

Image smoothing suppress the noise of the image ad suppress the small fluctuation in an image. The image enhancement improves the perception of an image.

To improve the image perception smoothing filter such as media, Gaussian, Gabor and histogram, equalization techniques were mostly used.

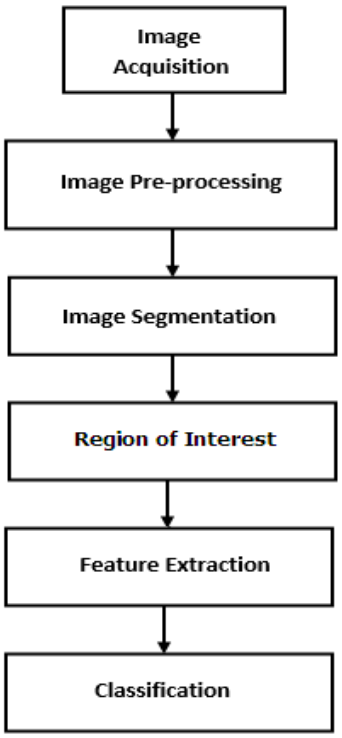

Figure-1 Generalized Brain tumor detection system Using medical images

2.3 Image Segmentation

Image segmentation is a process where the image is divided into smaller part and then classified according to the application. Image segmentation is a crucial process for most image analysis consequent tasks. The accuracy of the system mostly depends on the segmentation results.

Methods such as thresholding, watershed algorithm, region growing algorithm can be used for segmentation purpose.

2.4 Feature Extraction

This stage is a crucial stage that uses algorithms and techniques to discover and isolate numerous desired parts or shapes of a given image. Once the input file to associate degree formula is just too massive to be processed and it's suspected to be notoriously redundant, then the input data will be transformed into a reduced representation set of features. As the lung cancer tumors are generally spherical in shape, basic characters of feature extraction are area, perimeter and eccentricity.

2.5 Classification

The classification is the final step of the system. After analyzing the structure, each section individually evaluated for the probability of true positives.
There were many methods exist for the classification process. Some of them are, rule based methods, minimum distance classifier, cascade classifier, Bayesian classifier, Multilayer perception, Radial Basis Function network (RBF), Support Vector Machine (SVM), Artificial Neural Networks, Fuzzy logic etc.

3. MRI Segmentation techniques

A. REGION GROWING

Region growing segmentation method is the similar region segmentation method. Initially seed point is the considered and with reference to the seed point the similar pixel grouped to that region

and non similar pixel are grouped into other region.

The region growing algorithm is vastly used in the medical field. Application of the region growing segmentation algorithm in the medical field like brain tumor segmentation, kidney segmentation, cardiac image, lung cancer segmentation etc. the main disadvantage of this algorithm is seed point selection. Because it requires selecting seed point manually and thus there is a chance of wrong selection of region [1].

B. THRESHOLDING METHOD

The thresholding approach for image segmentation is one of the simplest methods among the segmentation technique. Thresholding is the separation of pixels in different classes depending on the intensity level of pixel. The main disadvantage of this method is the image can be segmented into two classes only and can't be applied to multichannel image. In this technique the image is classified into two classes so there is thresholding of MR images ignores the tumor cells [2].

C. WATERSHED

Watershed method is based on the gradient based technique. In this method gradients values are considered as different height. The concept came from the drop of water spreading over maximum surface. In short, the water droplets follow the gradient of the picture flow on a path and spread over maximum area.

There are different technical definitions of a watershed. The watershed line may be defined on the basis of edges, nodes or both. It is also defined in continuous domain [3].

D. ACTIVE CONTOUR

The active contour model is a framework for delineating an object's outline of an image. This method is also known as a snake's model. This method is popular in computer vision. This model used in various applications such as object tracking, edge detection, stereo image matching. Shape recognition.

We can viewed grayscale image as a topographic surface where higher intensity denoted as peak and lower intensity denoted as valleys. The field is marked with different color water (label) starting from valley to peak. But at the peak two regions start to merge. To avoid the merging, barrier to be build near merged region. The process goes for whole image. This process of separation area and labeling is called as watershed algorithm.

E. Mean shift

Mean shift is one the brain tumor segmentation technique. Mainly cluster analysis is used in this method. The mean shift algorithm used for clustering the dataset. The process starts with defining the spherical window of radius r then calculate the mean points in the window. The spherical window move to the next position by considering next mean and the process is repeated until convergence. In every iteration the window finds maximum peak and reach at a dense position.(5)

F. FUZZY C-MEAN CLUSTERING

In fuzzy C – mean clustering technique dataset is grouped into different n number of clusters. Each data point is considered as a cluster at a certain degree. This technique is also called as a soft clustering method.

FCM algorithm is a partition of n element X = {x1, x2, x3, …,xn} into a collection of c fuzzy structure according to given below criterion. [6] [7]

$$J = \sum_{i=1}^{N}\sum_{j=1}^{C} u_{ij}^{M} | x_i - y_i |2$$

Where,

M = fuzzy level

u_{ij} = membership of x_i in cluster c_i.

X_i = data value

Fuzzy c mean is a useful method for segmentation of medical images, but it is not useful for noisy image.

A review of various thresholding technique is tabulated below

Author	Summary	Proposed technique	Algorithm	Advantages	Future Scope
Wankai Deng (2010) [6]	MR image segmentation	Segmentation of brain MR images	Adaptive region growing segmentation	The algorithm is simple and effective.	The proposed algorithm more general and complete pathologic information into account, making it efficient and easy to implement the segmentation. So it deserves our further research
R. B. Dubey (2009) [7]	MR image segmentation	Brain MRI image segmentation	Region growing algorithm	Satisfactory segmentation results	Improvement of segmentation
Ewelina PIEKAR (2013) [8]	MR image segmentation	Brain tumor segmentation	Region growing method	Region growing method works relatively fast	The planned software-assisted selection of the seed point may contribute to improved operation of the algorithm
Roopali R.Laddha (2014) [9]	MR image segmentation	Brain tumor segmentation	Thresholding, watershed and morphological operation	The combination of thresholding, watershed and morphological operation improves the accuracy	
Roshan G. Selkar (2014) [10]	MR image segmentation	Brain tumor segmentation	Thresholding and watershed	upper section which shows the efficient tumor detection by using thresholding algorithm rather than watershed algorithm and also finding the boundary extraction of tumor by using a canny edge detection operator	
Deepthi Murthy T.S.(2014) [11]	MR image segmentation and classification	Brain tumor segmentation and feature extraction	Thresholding and morphological operation	Some of the features of the tumors are extracted which will be helpful in medical applications	Involve the segmentation of more images with more features which helps in classifying different types of tumors.

HUM YAN CHAI [12]	Brain Tumor Image Segmentation	Brain Tumor Image Segmentation	Preprocessing using wiener filter and nonlinear anisotropic diffusion and segmentation using region-based active Contour	Image quality in terms of SNR is improved using the proposed preprocessing method which is the combination of wiener filter and nonlinear ADF.	
Liang Zhao (2012) [13]	Brain Tumor Image Segmentation	Brain Tumor Image Segmentation	GMM and active Contour method	The accuracy is very good having specificity of 99.9%	
Jainy Sachdeva (2012) [14]	Brain Tumor Image Segmentation	Brain Tumor Image Segmentation	Content-based active contour model	Reduces the over segmentation problem.	This work can be further extended for complete 3-D segmentation by making use of an active surface in place of an active Contour.
Vishal B. Padole (2012) [15]	Brain tumor detection	Brain tumor detection	Mean shift algorithm and Normalized cut (Ncut) Method	Mean shift algorithm accurately segment the homogeneous area	To minimize the segmentation of Ncut method

4. BRAIN TUMOR CLASSIFICATION METHODS

A. KNN

KNN is simplest classification techniques for brain tumor classification. It provides good accuracy [18]. The KNN algorithm is based on the Euclidian distance of the nearer feature. KNN has good accuracy and stability for classification of MRI data.

The steps include in KNN are enlisted below:-

1. Calculate the K value
2. Calculate distance between testing sample and training samples.
3. Sorting the k^{th} distance and find out the minimum distance k^{th} value.
4. Assign value of majority class
5. Determine the class
6. Segment the abnormality of Brain MRI Image.

B. SVM

SVM is a supervised machine learning algorithm. The SVM was first developed by Vapnik and Lerner in 1998. SVM works under the principle of statistical learning theory.

The basic SVM classifier takes an input data from feature set. The next step is prediction of input data and classify into two possible classes. Besides linear SVM, nonlinear SVM works on high dimensional feature sets.

To increase the margin of the classification, kernel is used to control classification. There are many kernels used in support vector machine such as radial basis function (RBF), linear, polynomial etc. Among them radial basis function gives better performance on MRI brain Images. [16]

C. PCA

The feature extracted from database image have a large data. To compress or minimize the feature sets the principal component analysis technique is the best technique [17]. PCA is also known as discrete karhunen-Loeve transform.

The steps of PCA are enlisted below

1. Conversion of 2D image into 1D image.
2. Calculate the mean value of 1D image
3. Calculate difference matrix.
4. Find conversion matrix C = I*I
5. Find Eigen vector for each 1D image by using eig(C).
6. Find Eigen face by multiplying Eigen vector and 1D image I.

The results of the PCA are in the form of component score also called factor score.

D. Probabilistic Neural Network (PNN)

The brain tumor classification can also be carried out by probabilistic Neural Network (PNN). It is a machine learning algorithm used for classification of brain tumor based on training and testing network. The classifier can be applied to brain MRI images to classify into different class like benign, malignant or normal [19].

CONCLUSION

Image segmentation is the crucial task as medical images are concerned. The accurate segmentation is needed. This review paper gives the detail idea of brain tumor segmentation and classification techniques.

Medical image processing and analysis is active and fast growing field. The image processing techniques are able enough able to process the medical image.

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