MRI Tumor Segmentation – An Application Approach

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Abstract

**Introduction:** The Image segmentation is an important tool in Biomedical Engineering. The Image segmentation is generally done based on Edge based and Region based of an Image. The Image segmentation can be called as assigning label to each and every pixel of the image using various digital processing techniques. The choice of selection of image segmentation is done by low loss of pixel data and low percentage of degradation of pixel.

**Aim:** To segment and classify the brain tumor MRI images using PCA and SVM techniques. The GUI based app is developed using MATLAB software to make the segmentation easier. Through this app, the brain tumor image is loaded, segmented and classified as benign and malignant. Based on the segmentation, the benign and malignant tumor image features like mean, variance, kurtosis, contrast, homogeneity are extracted.

**Materials and Methods:** The Brain tumor MRI images were obtained from authorized database [Images taken from mri-scan-img.info MRI image database-https://www.oasis-brains.org/] for image
segmentation and analysis. Totally ten benign and ten malignant images are obtained. The GUI is developed using MATLAB 2017 version. Using the GUI, the input images are uploaded, segmented and classified. The GUI also consists of options of showing the feature extracted values from the input uploaded image. The general features of the image like Mean, Variance, Standard Deviation, Contrast, Correlation, Energy, Entropy, Homogeneity, RMS, Kurtosis – are viewed on GUI screen.

**Results:** The segmented images of all 10 benign and 10 malignant images are obtained from the GUI from MATLAB 2017 (software). The analysis part is done purely based on classified image and its extracted feature values.

**Conclusion:** Based on the classifier and segmented images obtained as output from GUI, the diagnosis of the tumor and tumor growth is diagnosed. The GUI is very recent in MATLAB application of Medical Image Processing. This GUI will make the processing time in seconds and has got increased accuracy on comparing with the accuracy of the papers mentioned in the literature survey. The GUI makes the Biomedical Engineers and image analyzers very easy to work on any kind of medical segmentation.

**Keyword**- Magnetic Resonance Imaging (MRI) Principal Component Analysis (PCA), Support Vector Machine (SVM), Graphical User Interface (GUI).

### I. Introduction

The digital image segmentation techniques follow only two algorithms for segmentation 1. Edge Based, 2. Region Based. Image segmentation refers to the process of partitioning a digital image into multiple segments that is set of pixels, pixels in a region are similar according to some homogeneity criteria such as color, intensity or texture, so as to locate and identify objects and boundaries in an image. The choice of a segmentation technique over another and the level of segmentation are decided by the particular type of image and characteristics of the problem being considered. Segmentation of an image based on changes in intensity of the image that includes edge-based segmentation. Segmentation of an image based on set of defined or pre-defined criteria’s like thresholding, region growing, region of interest, cropping etc [1][2] [The source of the literature is taken from “Review of Image Segmentation Techniques”, International Journal of Advanced Research in Computer Science” Vol-8, No-4, May 2017 Special Issue, ISSN No:0976-5697 and “MRI Segmentation of the Human Brain: Challenges, Methods and Applications”, Computational and
Brain MRI segmentation is a very useful tool for clinicians as well as biomedical engineers to visualize and analyze the structure of brain, study of anatomical planes, study on lesions, tumors, image guided interventions and surgical planning. MRI is a 3-D imaging modality which plays a crucial role in the analysis and diagnosis of tumors. It is one of the most advanced and innovative technologies which is significant for detecting soft tissue abnormalities. MRI is preferred over other imaging techniques such as X-ray, CT, Ultrasound for obtaining high contrast medical images. MRI parameters such as T1, T1 contrast, T2, FLAIR, PD (proton density) are used for detecting and diagnosing several neurological disorders such as stroke, cysts, tumor, Parkinson’s and Alzheimer’s diseases. High fatty tissues that occupies most part of the brain appears bright and the water-filled compartments appears dark. Thus, for high resolution and clarity, T1 weighted images are well suited [2] [6]. Tumor, also called neoplasm or lesion, is a sudden abnormal growth of tissue due to uncontrolled cell division.

To each image element is assigned a single value based on the average magnetic resonance characteristics present in the tissue corresponding to that element. The size of the element determines the spatial resolution, or the fineness of detail that can be distinguished in an image. Voxel/pixel sizes vary depending on imaging parameters, magnet strength, the time allowed for acquisition, and other factors, but often in standard MRI studies voxel sizes are on the order of 1-2 mm. Greater spatial resolution can be obtained with a longer scanning time, but this must be weighed against patient discomfort. In adult brain MRI studies image acquisition time is around 20 min, while in pediatric MRI studies image acquisition time is limited to between 5 and 15 min. Fundamental components of structural brain MRI analysis include the classification of MRI data into specific tissue types and the identification and description of specific anatomical structures. Classification means to assign to each element in the image a tissue class, where the classes are defined in advance. The problems of segmentation and classification are interlinked because segmentation implies a classification, while a classifier implicitly segments an image [1][2].

Brain tumors are of two types namely benign tumors and malignant tumors which are given below in Fig/Table1.
Swati Madhukar et al (2017) in this paper “GUI Based Automated Brain Tumor Detection and Segmentation” proposed a brain tumor detection system improved with segmentation of preprocessed image by advanced K-means algorithm and fuzzy c-means algorithm followed by object labeling and feature extraction. Features extracted by thresholding is used to train SVM and the database of the feature is used for pattern matching and to test the system. Finally, approximate reasoning by binarization method is used to recognize the shape of the tumor and its position in MRI image using SVM [2].

Kailash D. et al (2016) in this paper “Feature Extraction and selection from MRI Images for the brain tumor classification” mainly focused on brain MRI images feature extraction by PCA and GLDM algorithms, reduction of extracted features and selection of optimized features using genetic algorithm along with the joint entropy for classification using support vector machines [3].

Sonu Suhag et al (2015) in this paper “Automatic Detection of Brain tumor by image processing in MATLAB” proposed an algorithm in GUI for the detection and classification of tumor and non-tumor images from MRI scanned brain images using a SVM classifier [4].

Swapnali Sawakare et al (2014) in this paper “Classification of Brain Tumor Using Discrete Wavelet Transform, Principal Component Analysis and Probabilistic Neural Network” proposed an automatic support system for brain tumor stage classification using artificial neural network as well as presented k-means clustering segmentation algorithm to detect the Brain Tumor in its early stages and to analyze anatomical structures [5].

M. Karuna et al (2013) in this paper “Automatic detection and severity analysis of brain tumor using MATLAB” proposed an algorithm which incorporates segmentation through Neuro Fuzzy Classifier. The problem with this system is that, to train the system by neural network and many input
images are desired for use to train the network. The system thus developed is only used to detect tumors and not for other abnormalities [6].

Amer Al-Badarneh et al (2012) in this paper “A Classifier to Detect Tumor Disease in MRI Brain Images “proposed a system for classification of MRI images of brain tumor using neural network (NN) and K-Nearest Neighbor (K-NN) algorithms. This approach has achieved 100% classification accuracy using K-NN and 98.92% using NN[7].

In this paper we have taken 10 benign and 10 malignant images for Image segmentation. In our research the segmentation starts with the preprocessing, segmentation and accuracy verification. The preprocessing techniques involves Otsu Binarization.

II. Materials and Methods

The proposed method consists of a set of stages for the detection and classification of brain tumor by using classifier. The MRI image is given as an input in which Otsu Binarization for image thresholding is performed and the features (Mean, variance, Standard Deviation, Skewness, Kurtosis, Contrast, Correlation, Entropy, RMS, Homogeneity, Energy) are extracted using 1D Multi-Signal Wavelet transform. The extracted features are stored and selected by principal component analysis (PCA) which are classified as benign or malignant tumors by training the SVM classifier. The proposed methodology is represented as a block diagram in fig2 given below:

For feature selection 1D multi-Signal wavelet packet decomposition and for classification PCA and SVM classifier are used respectively. Principal component analysis is a variable reduction
technique which uses sophisticated mathematical principles to transform highly correlated variables and analyzed data into principal components. PCA is computed by the equation:

\[ \alpha_k' x = \sum_{j=1}^{p} \alpha_{kj} x_j \]

Where, \( x \) – \( p \) random variables vector  
\( \alpha_k \) – \( p \) constant vector

Support vector machine is a supervised machine learning, where the computer seeks the ability to learn without the program being performed. This linear classifier has the ability to simultaneously shrink the classification errors and expand the geometric margin. SVM is a binary classifier which assigns two sets for the input data, ‘0’ for benign and ‘1’ for malignant. The SVM classification function is given by the equation:

\[ c = \sum_i^s \alpha_i k(s_i , x) + b \]

Where, \( s_i \) - support vectors  
\( \alpha_i \) – weights  
\( b \) - bias  
\( k \) – kernel function

**Otsu Binarization:** This Algorithm performs the thresholding of image using foreground and background pixels. It calculates the optimum threshold separating the two classes so that their combined spread (intra-class variance) is minimal, or equivalently (because the sum of pairwise squared distances is constant), so that their inter-class variance is maximal.

**1D-DWPD:** The 1D-Multi-Signal Wavelet Pack et Decomposition is a simple algorithm for extraction of feature from an image. Based on the window size and increment between the windows and sampling frequency the function is performed to extract the feature from the image. In image analysis technique, feature extraction is classified into spatial features, transform features, shape features, edges and boundaries, intensity and texture features [18]. The image properties are reflected by different surface parameters.

This paper focuses on intensity and texture features of an image. Mean, variance, skewness, standard deviation are the intensity feature parameters, [19] whereas the contrast, correlation, energy, entropy and homogeneity are texture feature parameters. Apart from these parameters, RMS, smoothness and kurtosis features are also extracted. All these features are derived based on Co-
occurrence matrix which indicates the co-occurrence of features [6]. The surface parameters of the MRI image obtained in this research as follows:

**Mean:** An average or mean value of arrays which depends on the homogeneity of brightness of the image.

\[
\text{Mean} = \sum_i \sum_j g(i, j)
\]

Where, \( g(i,j) \) represents the features of co-occurrence matrix.

**Variance:** The heterogeneity is calculated by variance, which is correlated strongly with standard deviation.

\[
\text{Var} = \sum_i \sum_j (i - \text{mean})^2 g(i, j)
\]

**Skewness:** The measure of symmetry or asymmetry of a distribution or dataset around the sample mean.

\[
s = \frac{E(x-\mu)^3}{\sigma^3}
\]

**Standard deviation:** The square root of variance is termed as standard deviation.

\[
\sigma = \sqrt{\frac{1}{N} \sum_{i=1}^{N} |A_i - \mu|^2}
\]

**Contrast:** The presence of variations in the gray levels of the image is measured by contrast.

\[
\text{Con} = \sum_i \sum_j (i - j)^2 g(i, j)
\]

**Correlation:** Correlation is a dimensionless quantity and are standardized covariances that quantifies the degree of linear relationship between two random variables.

\[
\rho(A,B) = \frac{\text{COV}(A,B)}{\sigma_a \sigma_b}
\]

**Energy:** Energy measures the similarity in pictures under vitality by mirroring the replications of pixel pair.

\[
\text{Energy} = \sum_{ij} (g(i,j))^2
\]
**Entropy:** Entropy calculates the dissimilarity in the images or region of interest. Thus, entropy and energy are inversely proportional to each other.

\[
\text{Entropy} = \sum_i \sum_j g(i,j) \log(g(i,j))
\]

**Homogeneity:** Homogeneity is the inverse difference moment technique of the contrast which measures the neighborhood consistency of an image by assigning larger values for few gray level contrasts within the pixel pairs.

\[
\text{Homogeneity} = \sum_i \frac{1}{1+(i-j)^2} g(i,j)
\]

**RMS:** The root-mean-square of the values given in the form of a matrix, vector or scalars (discrete set of values) is computed by RMS.

\[
x_{\text{RMS}} = \sqrt{\frac{1}{N} \sum_{n=1}^{N} |x_n|^2}
\]

**Kurtosis:** Kurtosis is the measure of the outliers of a data or distribution.

\[
k = \frac{E(x-\mu)^4}{\sigma^4}
\]

### III. Results and Discussion

In this research, 10 benign brain tumor images and 10 malignant brain tumor images were taken. Through GUI based application, all these tumor images were loaded one by one, segmented and classified as benign or malignant tumor conditions. Simultaneously, the image features such as mean, SD, variance, contrast, energy, skewness etc. for both benign and malignant tumors were extracted, tabulated in table 1 and table 2 along with the corresponding graphs plotted in fig 3 and fig 4 which are given below:
Fig/Table 3: Graphical features of benign tumor

Fig/Table 4: Graphical features of malignant tumor
<table>
<thead>
<tr>
<th>Images</th>
<th>Mean</th>
<th>SD</th>
<th>Entropy</th>
<th>RMS</th>
<th>Variance</th>
<th>Smoothness</th>
<th>Kurtosis</th>
<th>Skewness</th>
<th>IDM</th>
<th>Contrast</th>
<th>Correlation</th>
<th>Energy</th>
<th>Homogeneity</th>
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<td>0.0981</td>
<td>0.0080</td>
<td>5</td>
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<td>6</td>
<td>0.9032</td>
<td>6.232</td>
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</table>
The MRI of brain tumor images are given as input to the application-based segmentation in Matlab. The input images are processed in matlab where the tumor region alone is segmented and features like mean, variance, etc are extracted from the images. Based on extracted features and segmented image threshold the benign and malignancy are classified using the PCA and SVM classifier. From the table 1 and table 2, it is very clear that the RMS values of benign and malignant tumors are same whereas the other extracted feature values differ. Finally, the graphs are plotted based on the tabulated feature values in fig 3 and fig 4.

<table>
<thead>
<tr>
<th>Image</th>
<th>Mean</th>
<th>SD</th>
<th>Entropy</th>
<th>RMS</th>
<th>Variance</th>
<th>Smoothness</th>
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</table>

**Figure/Table 5:** Statistical features of benign tumor

**Figure/Table 6:** Statistical features of malignant tumor
IV. Conclusion

The importance of medical image processing is getting increased day by day. The doctors ask for more accuracy and easy tool for medical image processing. In such case an application-based approach will be easy for the physician to analyze and diagnose the medical images. In this paper we aimed to develop an application based easy tool to segment the MRI tumor image. The proposed method mainly focuses on the GUI based MATLAB app which has been developed for the detection, segmentation and classification of brain tumor from MRI images within a short span of time based on feature extraction and selection through PCA algorithm and the appropriate features selected were classified by SVM classifier. As we come to the conclusion that application approach of medical image processing is much needed for the physicians and technicians for easy and fast processing of data. The accuracy of this method was 70% when run on a dataset of 20 images. In future, this work can be extended for detection, segmentation and classification of tumor for more than 20 brain tumor images which would provide efficient results for accurate diagnosis of tumor in various regions and other modalities.

REFERENCES


