BRAIN IMAGING GENOMICS BY FFBNN CLASSIFIER

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Abstract: At present day technology brain imaging genomics is the emerging technology for detection of brain tumor by integrating brain imaging and genetic science knowledge. detection of Brain tumor at its early stage will reduce the death rates. In this paper a novel technique using combination of multi-SVM classifier and FFBNN is developed to classify different types of tumors like benign, meningioma and pituitary tumor simply and accurately. The developed algorithm undergoes three stages 1.Pre-Processing, 2. Segmentation, 3. Classifier using Multi-SVM and FFBNN. As a Pre-processing step Nonlinear spatial filter is used to remove artifacts present in input image. For segmentation of tumor and non-tumor region an Adaptive fuzzy C-means algorithm is applied. For better classification accuracy genomics database of patient along with Multi-SVM and FFBNN classifiers are applied. In this paper an algorithm in Matlab with user friendly GUI is developed for the detection and classification of brain tumor.

Index Terms – FFBNN, GUI, MRI, Multi-SVM, Tumor, etc.

1. INTRODUCTION

Brain tumors are abnormal cells that grow in the brain and can cause serious damage. Brain tumors can be either malignant or benign. Benign tumors cause less harm than compared to its malignant counterparts. Malignant tumors easily spread into other tissues adjacent to it or to other distant body parts. Based on the location of origin of the tumor it can be primary or metastatic. Primary brain tumors originate in the brain and may or may not spread to other body parts, whereas secondary or metastatic tumors originate in other parts of body and then spread to the brain. The symptom having of brain tumor depends on the location, size and type of the tumor. Symptoms occur when the tumor compresses the surrounding cells and gives out pressure. Besides, it also occurs when the tumor blocks the fluid that flows throughout the brain. The common symptoms are having headache, nausea and vomiting, and having problem in balancing and walking. The automated techniques should be self-explanatory and easy to operate for the radiologists.

Types of tumor are:

i) Glioma

Glioma is a type of tumor that occurs in the brain and spinal cord. Gliomas begin in the supportive cells surrounding nerve cells and help them function.

ii) Meningioma

Meningioma, also known as meningeal tumor is a slow growing tumor that forms from the meninges, a membranous layer surrounding the brain and spinal cord.

iii) Pituitary tumor

Pituitary gland is in the skull, below the brain and above the nasal passages. Pituitary tumor may or may not be cancerous.

2. RELATED WORK

In brain tumor segmentation, we find several methods that explicitly develop a parametric or non-parametric probabilistic model for the underlying data. These models usually include a likelihood function corresponding to the observations and a prior model. Being abnormalities, tumors can be segmented as outliers of normal tissue, subjected to shape and connectivity constrains. Other approaches rely on probabilistic atlases.

Parveen and Amritpalsingh [1], proposed data mining methods for classification of MRI images. Classification is performed in four stages: pre-processing, segmentation, feature extraction, and classification. In the first stage, enhancement and skull stripping is examines the Kernel performed to improve the speed and accuracy. Segmentation was done by Fuzzy C-Mean (FCM) clustering. Gray level run length matrix (GLRLM) is used for extraction of feature from the brain image, after which SVM technique is applied to classify the brain MRI images, which provide accurate and more effective result for classification of brain MRI images.

Kailash Sinha and G.R.Sinha [2], presented a comparative study of three segmentation methods implemented for extraction of tumor in the MRI images. Proposed methods are k-means clustering with watershed segmentation algorithm, optimized k-means clustering with genetic algorithm and optimized c- means clustering with genetic algorithm. For comparison, the searching time and area of tumor region were considered as comparison parameters. Results depict that, clustering algorithm in case of optimized method perform much better segmentation than that of ordinary clustering algorithm. The problem of over segmentation has also been reduced. Also it is found that the optimized c-means perform better that optimized k-means method.

Dr.G.Padmavathi, Mr.M.Muthukumar and Mr. Suresh Kumar Thakur [3], in their paper examines the Kernel Principal Component Analysis (KPCA) feature detection and classification for underwater images.

Zhang. Y. J [4], in his paper, statistics for a number of developed algorithms is provided, the scheme for classifying different segmentation algorithms is discussed.

Wahba Marian [5], in her paper proposed a new approach for automatic prostate segmentation of Trans-Rectal-Ultrasound (TRUS) images by dealing with the speckle not as noise but as informative signals.

3. METHODOLOGY

Detection of abnormalities is difficult due to the subtle nature of its progression and low contrast look. Current abnormality detection techniques use feature extraction and classification as the major steps. The accuracy of the detection depends on the kind of classifier used. Databases of patient images are taken as the reference for the accurate detection. All the images are weighted images with totally different views however constant resolution. The images endure a feature extraction method. Textural features are considered for the purpose of mild injury detection because texture features are able to determine small structural changes that occur within the brain. Succeeding step is that the feature classification. Classifiers are used to estimate the locations of lesion and therefore the normal appearing brain area.

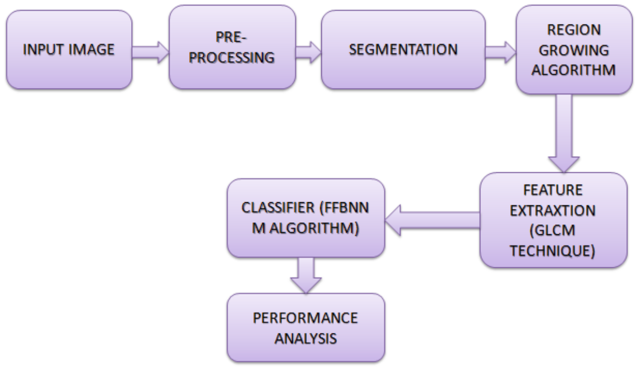

Figure 1: Block diagram

Image Acquisition: Image acquisition is the digitally encoded data of the brain. The MRI images are collected through an internet database. Out of the total images acquired half was used for the training phase and the remaining half for the testing phase.

***Pre-Processing**:* Preprocessing aims to selectively remove the redundancies present in the acquired images without affecting the details which play a key role in the overall process. Basic steps involve (i) Image Re-sizing: The original MRI brain image has a dimension of 256*256 pixels which is converted to a gray scale image of dimension becomes 128*128 pixels, (ii) Filtering: Noise reduction is done using a non-linear spatial filter that is a median filter, which computes the median gray level value for noise reduction and used to find out the various brightness levels in an image.

Segmentation: Segmentation in medical imaging is a complicating task for the exact identification of brain tumors. Several clinical trials are performed for the identification of the pattern of brain tumors. The main reason for segmentation is to partition the image into multiple segments which can be analyzed easily.

Each pixel of the image is assigned a label so that pixels having the same label show similar characteristics and properties. Fuzzy C-means clustering has been used in this work (as shown in figure 6), in which every point has a degree of belongingness to cluster for a given dataset. Segmentation in medical imaging is challenging and complicating task for the exact recognition of brain tumor. A number of clinical investigation/ trials are performed for the recognition of pattern of brain tumor. The main purpose of segmentation is to partition the image into multiple segments which makes more meaningful and easy to analyze. Each pixel assigning a label to the image so that pixel having same label show similar characteristics and properties. For the anatomical detailed information of brain images, mapping and identification of tumor clustering algorithm has been very effective.

Region Growing Algorithm: In the proposed work, a conventional region growing algorithm is used for the segmentation of brain tumor core due to simplicity and good performance. This technique group's pixels or regions that have similar properties based on predefined criteria. The intensity difference and neighborhood type for the images were defined. In this method, the difference of intensity is selected and the user may tune the parameter values of the vector. It starts with a set of initial seed points that represents the criteria and grows the region by appending to each seed's neighboring pixels that have similar properties with the seed. We can select the seeds either automatically or manually. The automated selection is based on finding pixels that are of interest. Conditions for this region growing method are as follows (i) indicates that the segmented image must be complete that every pixel must be in a region,(ii) requires that points in a region must be connected with some predefined ratio,(iii) indicates that the region must be disjoint,(iv) deals with the properties in a segmented region.

Feature Extraction: Feature Extraction is a method to capture the visual content of images for indexing & retrieval. Image features such as color, texture, and shape of a specific region in the brain. The Gray Level Co-occurrence Matrix (GLCM) is used as a feature extraction method. This method is used to examine the texture that considers the spatial relationship of pixels that is also known as the gray-level spatial dependence matrix. GLCM functions characterize the texture of an image by calculates how often pairs of pixels with specific values that occur in an image, creating a gray-level co-occurrence matrix, and then extracting statistical measures from the matrix.

$$C_{\Delta x,\Delta y}(i,j) = \sum_{x=1}^{n}\sum_{y=1}^{m}\begin{cases}1, & \text{if } I(x,y)=i \text{ and } I(x+\Delta x, y+\Delta y)=j\\ 0, & \text{otherwise}\end{cases}$$

For an image with *p* different pixel values, the *p* x *p* co-occurrence matrix **C** is defined over an *n* x *m* image **I**, parameterized by an offset (Δx, Δy), as:

Where: *i* and *j* are the pixel values; *x* and *y* are the spatial positions in the image **I**; the offsets (Δx, Δy) define the spatial relation for which this matrix is calculated; and **I**(*x*,*y*) indicates the pixel value at pixel (*x*,*y*).

In feature extraction, relevant information is extracted from input data. After feature extraction, a common method of selection is sequential forward selection (SFS). GLCM calculation of ten invariant features has been done which are as follows:

- Contrast
- Correlation
- Cluster prominence
- Cluster shade
- Dissimilarity
- Energy
- Entropy
- Homogeneity
- Maximum probability
- Variance
- Auto Correlation

Feed Forward Back-Propagation Neural Network (FFBNN): After the feature extraction, the Feed Forward Back-propagation Neural Network (FFBNN) is utilized to perform the classification process. FFBNN is made up of neurons which consist of learnable weights and biases. Each neuron receives some form of inputs. It performs a dot product and might follow it with a non-linearity. A Neural Network is comprised of one or more Convolutional layers and pooling layers followed by one or more fully connected layers as in a standard multilayer neural network. The application of convolutional layers consists in convolving a signal or an image with kernels to obtain feature maps. So, a unit in a feature map is connected to the previous layer through the weights of the kernels. The weights of the kernels are adapted during the training phase by back propagation, in order to enhance certain characteristics of the input. Since the same kernel is convolved over the entire image, the same feature is detected independently of the location– translation invariance. By using kernels, information of the neighborhood is taken into account, which is a useful source of context information. Usually, a nonlinear activation function is applied on the output of each neural unit. If we stack several convolutional layers, the extracted features become more abstract with the increasing depth. The first layers enhance features such as edges, which are aggregated in the following layers as motifs, parts, or objects.

Multi SVM Classifier: Support vector machine or the SVM is a part of machine learning that gives the computers the ability to learn. It is a method that analyzes the data pattern which is used for classification. In multi-SVM classifier, more than two classes are classified. Multi-SVM is used to classify various types of tumors like Gliomas, Meningioma, pituitary etc. SVM classifier is used to determine whether the MRI lesion is normal or abnormal. SVM is a binary classification method in which two classes for input data has been fixed. For normal case, symbol ‘0’ has been taken; whereas, for abnormal ‘1’ has been taken. The parameters from feature extraction are used for classification. They have their roots in Statistical Learning Theory and have gained prominence because they are robust, accurate and are effective even when using a small training sample. By their nature SVMs are binary classifiers, but, they can be modified to handle the multiple classification tasks. In addition to performing linear classification, SVMs can efficiently perform a non-linear classification using what is called the kernel trick, implicitly mapping their inputs into High-dimensional feature spaces. The clustering algorithm which provides an improvement to the support vector machines is called support vector clustering and is used in industrial applications either when data are not labelled or when only some data are labelled as a pre-processing for a classification pass.

Graphical user interface: GUIs (also known as graphical user interfaces or UIs) provide point-and-click control of software applications, eliminating the need to learn a language or type commands in order to run the application. GUIDE (GUI development environment) provides tools to design user interfaces for custom apps.

GUIDE then automatically generates the MATLAB code for constructing the UI, which can be modified to program the behavior of the developed software. This module of the GUI based automated detection and classification of the brain tumor works to differentiate between tumor and non-tumor cells. A user needs to click on different buttons in sequence to process a new MRI image of brain. After processing, tumor will be detected using both Support Vector Machine and Convolutional Neural Network. It will also display the various values of GLCM features like entropy, homogeneity, contrast, cluster prominence etc.

4. RESULTS AND DISCUSSIONS

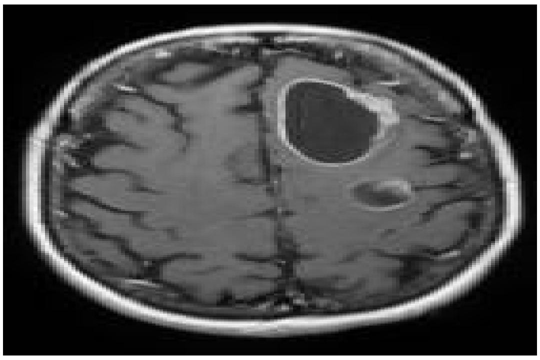

Figure 2: Testing input image

GUI is the interactive tool that enables the user for graphical display. This application has self-contained Matlab program with GUI [11]. GUI provides interactive tool for designing image processing morphological operation. This module of the GUI based automated segmentation and recognition of the brain tumor. A user needs to click on different buttons in sequence to process a new MRI image of brain as shown in figure 3 to 7.

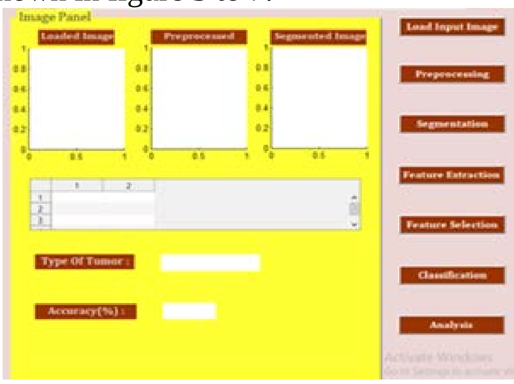

Figure 3: GUI Interface model

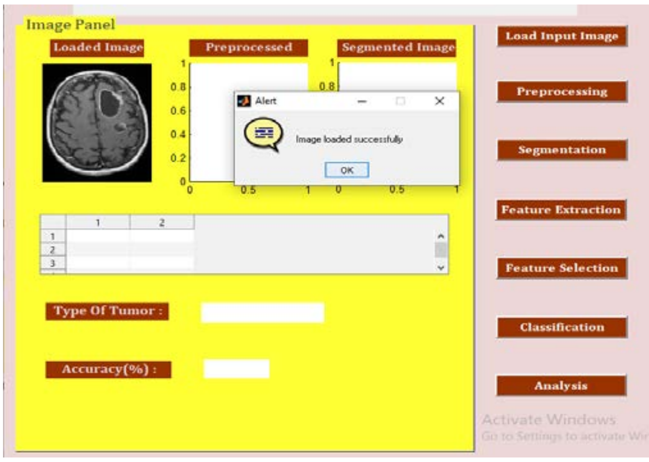

Figure 4: GUI model showing the load testing image

The pre-processing is done to de-noise the image and smoothing the edges using median filtering. After smoothening the image, the edges need to be isolated/extracted**.**

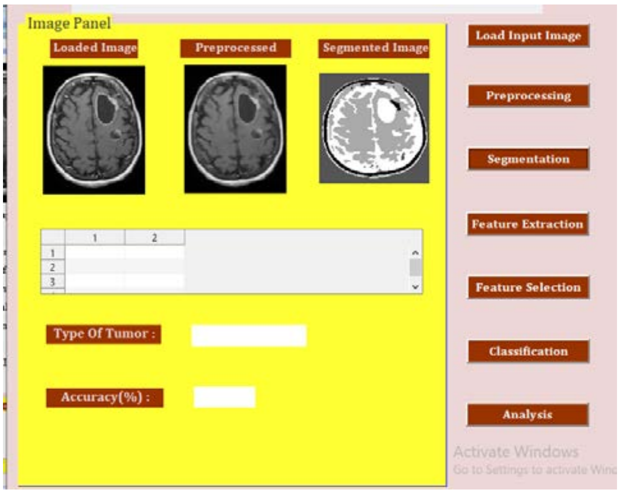

Figure 5: GUI model showing the loading segmented image

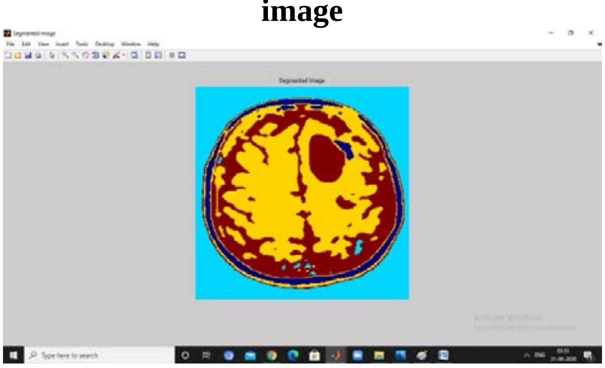

Figure 6: Segmented Image (a)

The image is loaded and the homogeneity criterion is selected. The intensity difference and neighborhood type for the images are also defined.

Figure 7: Segmented image (b)

The intensity difference is selected experimentally and the user may change the parameter values of the vector. Another stage is to define the seed point and the number of images in a series to be segmented. Then identify the seed points and extreme intensity values. Pixels in algorithm are a counter of pixels in segmentation region. When all the parameters are initialized the region growing method is operated. The method checks the point that is located closest to the seed point. If the point meets the homogeneity criterion it is added to the affected region. If the point does not meet homogeneity criterion then it will not be added to the affected region [6].Region growing based segmented image shown in figure 7.

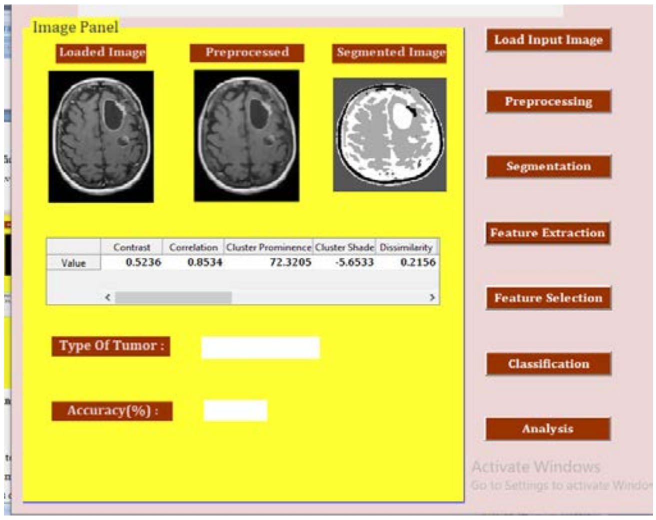

Figure 8: GUI model showing the feature extraction

For feature extraction GLCM technique has been used. A gray level co-occurence matrix (GLCM) contains information about the positions of pixels having similar gray level values [9]. The corresponding values of features of taken testing image shown in below table:

Contrast	0.5236
Correlation	0.8534
Cluster performance	72.3205
Cluster shade	-5.6533
Dissimilarity	0.2156
Energy	0.2420
Entropy	1.6734
Homogeneity(1)	0.9295
Homogeneity(2)	0.9223
Maximum probability	0.3141

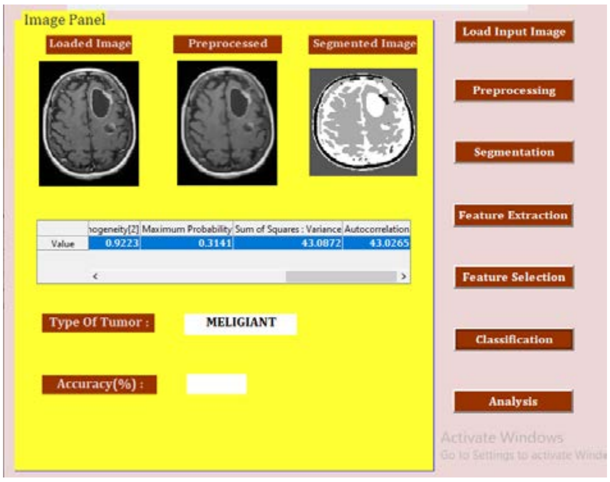

Figure 9: GUI model showing the type of tumor

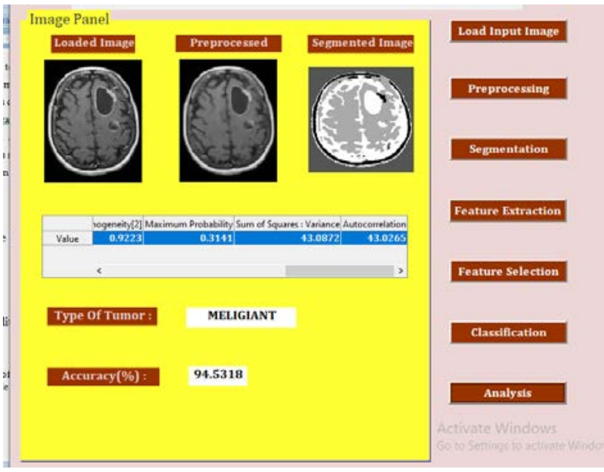

Figure 10: GUI model showing the Accuracy

Finally the accuracy of the method was 94.5318% when run on a dataset of images

5. CONCLUSIONS

The developed software will help in detection of tumor very easily which in turn will saves the precious time of doctors and pathologists to diagnose the tumor. Moreover, the tumors will be classified in a short span of time depending upon their characteristics and growth pattern. The FFBNN is observed to be more accurate and. In this paper an algorithm in Matlab GUI has been developed for the detection and classification of brain tumor from MRI scanned brain images based on various operation like preprocessing, segmentation, and feature extraction and by using SVM classifier. The accuracy of the method was **94.5318**% when run on a dataset of images. This work helps in detection of tumor which in turn saves the precious time of doctor and pathologist to diagnose the tumor and its classification automatically in short span of time.

Future scope of the proposed method is segmentation of the swelling surrounding the tumor core also known as Edema using images from different MR modalities.

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