Brain Tumor Segmentation and Classification using Hybrid clustering technique and SVM Classifier

Maibam Mangalleibi Chanu, Khelchandra Thongam

Abstract: ***Brain tumor Detection is a primary concern in today's life. So a computer aided technology must be implemented for an accurate detection and identification of brain tumor. The tumor can be detected using various classification techniques from brain MR Images. In this paper segmentation process is being done using K means Clustering technique and Binary Thresholding, the features from the images are then extracted using GLCM where six texture features are extracted and SVM Classifier is being used for classification of the images. This proposed method shows an accuracy of 97.12%.***

Keywords: ***GLCM (Gray Level Co-Occurrence Matrix), SVM (Support Vector Machine), MRI (Magnetic Resonance Imaging)***

I. INTRODUCTION

Tumor of a brain is an unrestrained growth of abnormal cells in the brain. Tumors normally develop within the brain from a malignant tumor found on different parts of the body. Tumors or cancerous cells have the potential to directly destroy normal and healthy brain cells. Brain tumors can occur at any location in the brain and can have a variety of shapes and sizes depending on the types of tumors. Tumors can be categorized either benign or malignant. The use of computer aided technology in the field of medical is now universal and pandemic across a huge coverage of medical area like research in cancer, gastroenterology, brain tumors etc.

Automated detection of brain tumor and identification is the field of interest in research nowadays using techniques like Magnetic resonance imaging (MRI). MRI is an advanced medical imaging technique that uses powerful and strong magnetic fields and high radio frequency waves in order to produce complete images of the internal body. We can obtain detailed anatomical information from these high resolution images to assess and examine the development of human brain and discover abnormalities from it. Several methodologies have been implemented for classifying MRI images like shape and size methods, fuzzy neural network methods, knowledge based techniques, deep learning neural networks, and various segmentation methods.

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The purpose and aim of this paper is detecting tumor in the brain using MRI images. The main reason for detection of brain tumors is to provide a better accuracy in detecting brain tumor which could help in saving many lives suffering from brain tumor. Also it will provide an aid to clinical diagnosis for better results and to obtain more accuracy in classification of brain tumor.

II. LITERATURE REVIEW

This MRI process is based on Magnetization properties of atomic nuclei. The magnetization is disrupted by an external Radio Frequency (RF) energy. Through various relaxation processes, the nuclei get back to their resting alignment and produces RF energy. After some amount of time and after the first RF, the produced signals are used for measurement. The tissue is categorized by two different relaxation times which are known as T1 and T2. The longitudinal relaxation time, T1 is the time constant which determines the rate at which excited protons return to equilibrium. It is a measurement of the time taken for rotating protons to re-align with the external or outer magnetic field. The transverse relaxation time, T2 is the time constant which shows the rate at which excited protons reach equilibrium or go out of phase with each other. It is a measure of the time taken for rotating protons to lose phase-coherence among the nuclei spinning at an angle of 90 degree to the main field.

In paper [1], Eman et al. uses K means integrated with Fuzzy C means for performing brain tumor segmentation. In paper [2], the authors used PCA (Principal Component analysis) and LDA (Linear Discriminant Analysis) for feature reduction and SVM (Support Vector machine) for classification.

Sanjeev Kumar in paper [3] uses DWT (Discrete Wavelet Transform) for feature extraction and Support Vector Machine classifier is being used for the purpose of Classification. Linear accuracy of this method ranges from 80% to 90%. In paper [4] K.Sudharani et al. use image processing techniques to detect brain tumor and to localize brain tumor region accurately. In paper [5] Kruti G et al. use tumor region extraction method and SVM classifier to classify different types of tumor.

III. PROPOSED METHODOLOGY

This proposed method uses brain MR Images from kaggle datasets. The data set includes both normal MR Images and Tumor Images.

Also real time MR Images from Babina Diagnostics Imphal is collected and performed the detection process which gives a higher accuracy with this algorithm proposed.

A. Preprocessing

The basic definition of image preprocessing refers to processing of digital image. The main purpose of preprocessing is to improve the quality of the MR images and make it in a form suited for further processing by human or machine vision system. It also helps to improve certain parameters of MR images such as improving the signal-to noise ratio, enhancing the visual appearance of MR image, removing the irrelevant noise and undesired parts in the background, smoothing the inner part of the region, and preserving its edges.

- BGR to Gary scale conversion: Digital images are displayed using a combination of red, green, and blue (RGB) colors, each pixel has three separate luminance values. Each color pixel in an image is described by a triple (R, G, B) of intensities for red, green, and blue. Some methods are average method, lightness method average, luminosity average etc.
- Bilateral Filtering: Bilateral filtering is one of the most popular image processing techniques. Its ability to decompose an image into different scales without causing haloes after modification has made it ubiquitous in computational photography applications such as tone mapping, style transfer, relighting, and de-noising.
- Erosion: Erosion is one of the two basic operators in the area of mathematical morphology, the other being dilation. It is typically applied to binary images, but there are versions that work on grayscale images. The basic effect of the operator on a binary image is to erode away the boundaries of regions of foreground pixels (*i.e.* white pixels, typically). Thus areas of foreground pixels shrink in size, and holes within those areas become larger.
- Dilation: It is typically applied to binary images, but there are versions that work on grayscale images. The basic effect of the operator on a binary image is to gradually enlarge the boundaries of regions of foreground pixels (*i.e.* white pixels, typically). Thus areas of foreground pixels grow in size while holes within those regions become smaller.

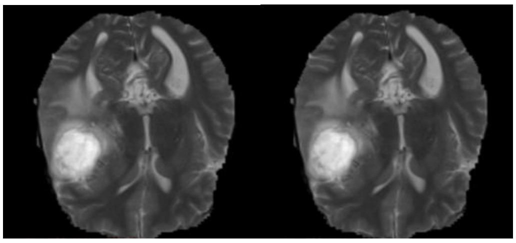

Fig.1: Input MR Tumor image &BGR to gray output

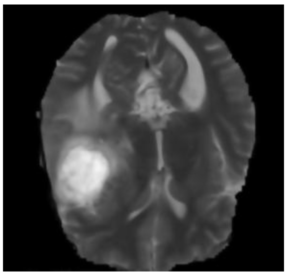

Fig.2: Output after Bilateral Filtering

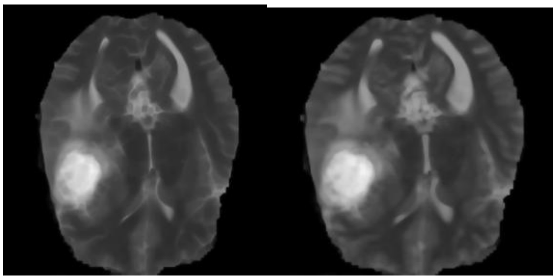

Fig.3: Output after Erosion and Dilation

B. Image Segmentation:

Image segmentation is the process of dividing an image into different regions such that each region is homogeneous. There are two ways of image segmentation. Firstly K-means clustering is performed. It is the simplest unsupervised clustering technique that can work for large number of variables and classifies the input data into multiple classes based on their inherent distance from each other. In k-means clustering, it clusters a given set of data using a certain number of classes based on the similarity between the given data and the classes centers [6],[7],[8].

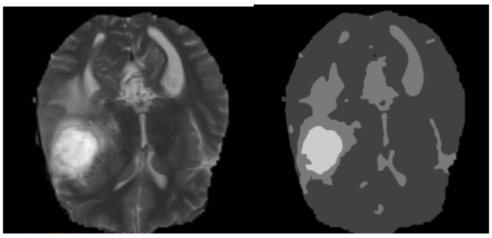

Fig.4: Left Image –Tumor Input Image and Right Image-Image after applying K-means.

Secondly we use Binary thresholding method for segmentation of MR images. Thresholding is a process of converting a grayscale input image to a bi-level image by using an optimal threshold. Thresholding creates binary images from grey-level ones by turning all pixels below some threshold to zero and all pixels about that threshold to one.

If g(x, y) is a thresholded version of f(x, y) at some global threshold T,

$$g(x,y) = \begin{cases} 1 & \text{if } f(x,y) \geq T \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

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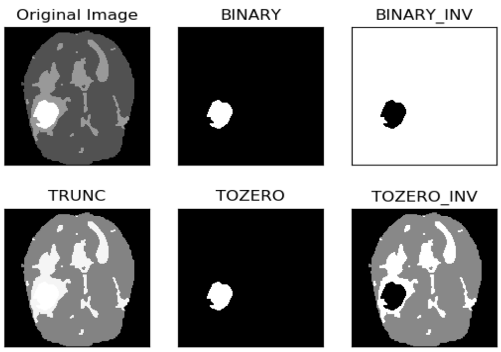

Fig.5: Output image after applying different styles of thresholding

C. Feature Extraction:

Feature extraction is a method of capturing visual content of images for indexing and retrieval. Before getting features, various image preprocessing techniques like binarization, thresholding, resizing, normalization etc. are applied on the sampled image. After that, feature extraction techniques are applied to get features that will be useful in classifying and recognition of images.

Gray Level Co-Occurrence Matrix (GLCM): It is a tabulation of how often different combinations of pixel brightness values occur in an image. In GLCM the number of rows and number of columns are the same value as the number of gray levels in the image. Co-occurrence matrices are constructed in four spatial orientations (0°, 45°, 90° and 135°). It represents the similarity and relation between two neighboring pixels, the first pixel is known as a reference pixel (*i*) and the second is known as a neighbor pixel (*j)* in various orientations. Initially, the values of each elements in the GLCM (i,j) is zero. The value of each element is updated as per the occurrence of pixels together.

Six texture features are calculated using GLCM [12], they are Contrast, Energy, Homogeneity, Correlation, Dissimilarity and Angular Second Moment (ASM).

$$\text{Contrast} = \sum_{i,j=0}^{N-1} P_{ij}\,(i-j)^2 \quad (2)$$

$$\text{Correlation} = \sum_{i,j=0}^{N-1} P_{i,j}\,\frac{(i-\mu)(j-\mu)}{\sigma^2} \quad (3)$$

$$\text{Homogeneity} = \sum_{i,j=0}^{N-1} \frac{P_{ij}}{1+(i-j)^2} \quad (4)$$

$$\text{Energy} = \sum_{i,j=0}^{N-1} {P_{i,j}}^2 \quad (5)$$

$$\text{ASM} = \sum_i \sum_j \{p(i,j)\}^2 \quad (6)$$

$$\text{Dissimilarity} = \sum_{i,j=0}^{N-1} P_{i,j}\,|i-j| \quad (7)$$

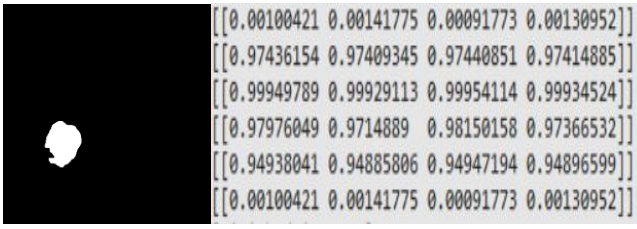

Fig.6: Segmented Image and its Features sfter GLCM

The features obtained here will be used for Classification through SVM classifier.

D. Classification:

In the classification stage the proposed methodology was able to differentiate between the normal and tumor images. Classification is done using Support Vector machine (SVM) for detecting the tumor images. An SVM model is a representation of the examples as points in space, mapped so that the examples of the separate categories are divided by a clear gap that is as wide as possible. New examples are then mapped into that same space and predicted to belong to a category based on which side of the gap they fall.

The SVM function defines a hyper plane which can be divided into two training classes as follows:

$$f(y) = Z_T\phi(y) + b \quad (8)$$

where Z and T are parameters of hyper plane and $\phi(y)$ is a function used to map vector y into a higher-dimensional space.

SVM classifier is widely used in the field of numerous research areas because of its high performance and the potential to take over other classifiers due to their ability of categorizing classes that are linearly or non-linearly distinguishable [9].

IV. RESULTS AND DISCUSSION

The results of the proposed methodology was obtained using OpenCV(Open Source Computer Vision Library), Python programing and various methods used for detection of the presence of tumors in MRI images. It shows a better performance than the existing methodologies. The MRI image dataset is divided into two parts: training set and test set. 70 percent of the dataset is used for training and remaining 30 percent is used for testing phase. The tumor images are labeled as '1' and the normal brain images are labeled as '0'. The SVM model takes a set of input data (feature values) and predicts for each given input, which of two possible classes (tumor or normal) forms the output. The output is in the form of 0(normal) or 1(tumor).

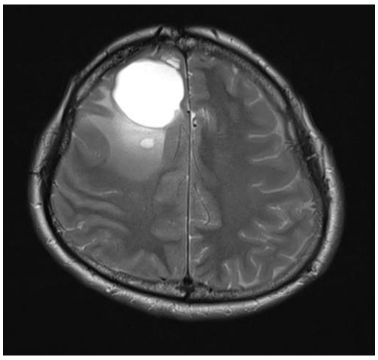

Fig.7: Test Image from the dataset

After applying SVM to the test image shown in fig.7 the result obtained is shown in fig.8. The value ‘1’ indicates that tumor is present in the test image.

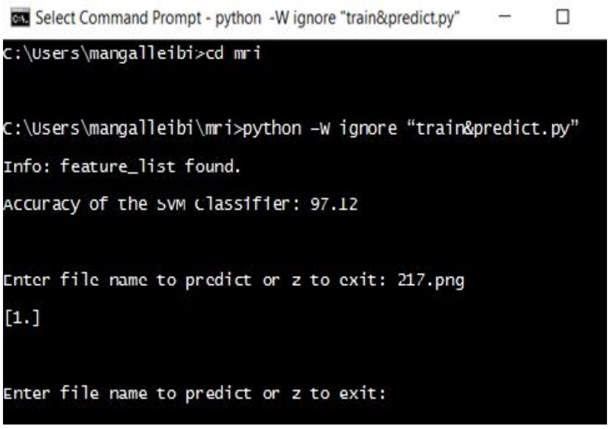

Fig.8: Tumor detection

Table- I: Comparison with other methodologies

Name of Methods	**Accuracy**
LDA+PCA+SVM[2]	96%
DWT+SVM[3]	80%-90%
BWT+SVM[9]	96.51%
Proposedmethod(K-Means+Binary Thresholding+GLCM+SVM)	97.12%

Table I shows the comparison with different methodologies and our proposed method has the highest accuracy in the comparison.

V. CONCLUSION

In this paper the proposed methodology classifies MR images into two classes normal and tumor patient. The algorithm works greatly for the segmentation of brain tumor MR images. The segmented images are used for feature extraction using GLCM which extracted six texture features. And detection of brain tumor is performed using SVM Classifier. The system evaluation shows high accuracy with 97.12% while comparing with other methods. In future work, our methodology may be implemented with other deep learning techniques which may result in higher accuracy for the system detection of brain MR images.

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