Brain Tumour Classification Using Machine Learning

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Abstract- *A Brain tumour is formed by a gradual addition of abnormal cells, and this is one of the major causes of death among other sorts of cancers. It is necessary to classify brain tumor using Magnetic Resonance Imaging (MRI) brain tumor image for treatment because MRI images assist as to detect the smallest defect of the body. This paper aimed to automatically classify brain tumours using a machine learning algorithm. In this work, the input image of the brain was pre-processed using median filter, segmented from the background using thresholding and Kmeans clustering algorithm and its features were extracted using GLCM. Using the SVM classifier, the brain tumour in the image was detected as either benign or malignant. This image classification process helps the doctors and research scientists to detect the tumour during its early stages, thereby controlling the spread of cancerous cells.*

Keywords- Brain tumour, Image processing, Feature extraction, Machine learning, Classification

I. INTRODUCTION

Brain tumour known as intracranial neoplasm, is an irregular tissue in this cell rapidly grow and differentiate unmanageably. This condition is naturally serious and critical due to its interfering and proliferative behaviour in the limited space of the intracranial cavity. Brain tumours can be malignant or benign. The elements like the type of tumour, its location, its size and its state of development are depending on its threat level. Classification of Brain tumours for treatment is important because MRI images assist us to detect the smallest defect in the body. The aim of this paper is to automatically classify brain tumours using a machine learning algorithm. In this work, the input image of the brain was pre-processed, segmented from the background and its features were extracted. This image classification process helps the doctors and research scientists to detect the tumour during its early stages, thereby controlling the spread of cancerous cells.

II. METHODOLOGY

Generally, diagnosing a brain tumour usually starts with magnetic resonance imaging (MRI). MRI Imaging plays an important role in brain tumour for analysis, diagnosis and treatment planning. The steps involved in detecting the brain tumour from MRI Images are given below.

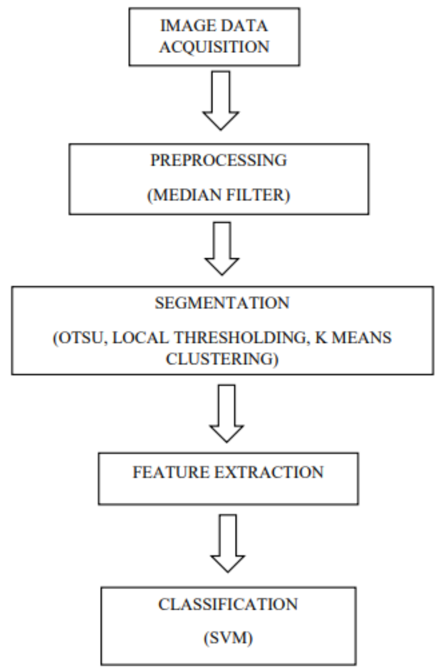

Figure: 1

The process begins with acquiring Image dataset. The transformations applied to the info before feeding it to the algorithm is understood as pre-processing. Objects and boundaries in images can be located by Segmentation process. The technique of dividing an image into regions is known as Image Segmentation. The division takes place on the basis of property of pixels of image. Feature extraction uses specialized algorithm to extract features automatically from signals or images without the need for human intervention. This technique will be very useful for quickly moving from raw data to the stage of developing machine learning algorithms. The process of classifying or predicting the class of a particular object in an image based on certain rules is known as image classification.

III. IMAGE DATASET ACQUISITION

A data set is a collection of data. The data are fundamentally arranged to a certain model that helps to process the required information. Kaggle functions as a community for data scientists and machine learning practitioners. For this work, we downloaded the dataset from Kaggle. In the dataset of 253 images of brain, we have used 15 images.

Pre-processing

The goal of pre-processing techniques is improving the image quality by suppressing unnecessary things or enhancing useful image features that is important for further processing. These techniques make the image acceptable for further processing and improves the quality of the image and finally removes the noise existing in the image. The pre-processing steps used were Grayscale transformation and Noise removal using Median filter. Grayscale transformation can significantly improve the viewability of an image as shown in Figure 2. Removal of noise is an important task in image processing for the further analysis of images. To reduce salt and pepper noise or impulsive noise, the median filtering process is useful as shown in Figure 3.

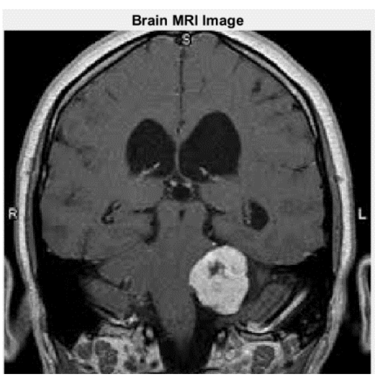

Figure 2 : Gray Scale Image

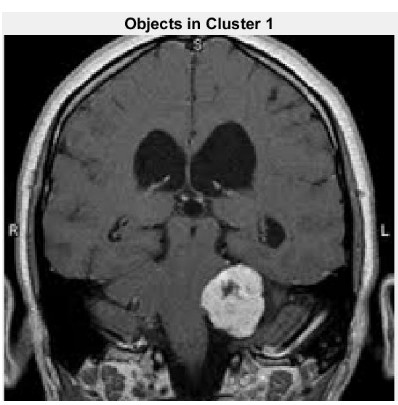

Figure 3 :Filtered Image using Median Filter

Segmentation

As we already know, the technique of dividing an image into multiples of segment is called Image Segmentation. Changing the representation of a picture into more meaningful and very easy to analyse is the goal of segmentation. The segmentation algorithms used were Otsu Thresholding, Local Thresholding and K-Means Clustering Algorithm.

Otsu is a type of global thresholding which is based only on gray value of the image. According to Otsu binarization, for an image, approximate value in middle of peaks is taken as threshold value. As it automatically calculates the threshold value, this method is also known as an automatic threshold selection region-based segmentation n. On the basis of interclass variance maximization, it is expected to detect optimal value for global threshold [2] [3]. The class that has larger variance determines the threshold, be it the background or the foreground as shown in Figure 4.

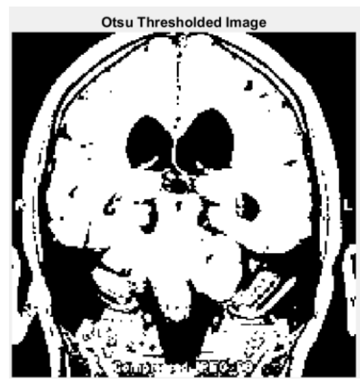

Figure 4. Segmented Image Using Otsu Thresholding

Local thresholding, which is a binarization process can convert the coloured image into binary image as shown in Figure 5. In this technique, based on the statistics such as variance, range of the neighbourhood pixels, threshold value is calculated for each pixel. This can be used for uneven illumination. Unique or specific threshold values is used for the partitioned sub images obtained from full image.

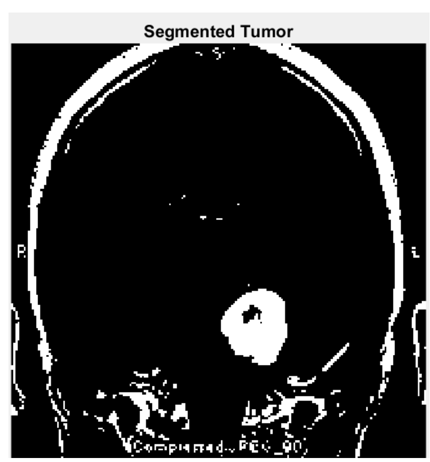

Figure 5. Segmented Image Using Local Thresholding

K Means is an unsupervised and clustering algorithm which implies that there is no labelled data present. It is used to identify different clusters in the given data based on similarity of data [2] [4] [6]. Furthermore, it is an iterative process that partitions the dataset according to their features into K number of clusters as shown in Figure 6.

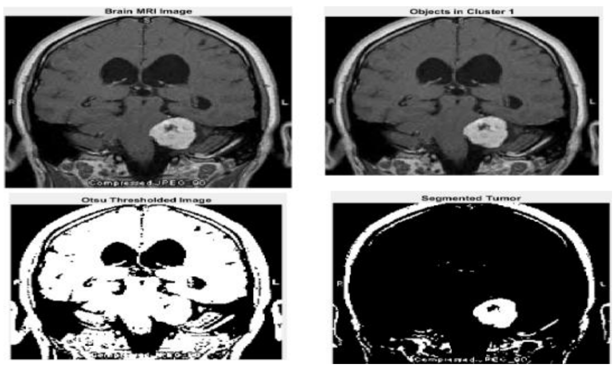

Figure 6. Segmented Image Using K-Means Clustering Algorithm.

Significance

Making the image analysis easy and meaningful is the main aim of segmentation. Because of its simple calculation, Otsu method is most successful. Regions of interest in images that exhibit non-uniform lighting changes, can be isolated using Local Thresholding. K-means algorithm of image segmentation segments the interest region from the background. The image is also contrast stretched so that the good quality image for segmentation can be obtained and is relatively simple to implement.

IV. FEATURE EXTRACTION

The segmented image is used for Feature Extraction. Feature extraction is employed to efficiently represent the image by capturing the important parts of the image. In this paper, we have extracted the features using DWT and GLCM.

The DWT Wavelet transform is an effective one to represent the image. In this DWT process, analysis filter bank and decimation techniques analyse the image. This filter bank contains low and high pass filters pairs. The detailed information of the image is extracted by low pass filter and the information about edges are extracted by high pass filter. The multi-level determination of the image is permitted by DWT. The goal is to extract relevant data from an image. DWT Wavelet transform samples the wavelets at discrete intervals. At the same time, it provides information about spatial and frequency of the image.

GLCM means gray level cooccurrence matrix. This function distinguishes the texture of the image by determining how frequently a pair of pixels with some values and in a defined spatial relationship exist in an image. In this, GLCM is created using Gray-comatrix and the statistical measures are extracted using Graycoprops. The extracted features include Contrast, Energy, Correlation, Smoothness, Standard Deviation, Homogeneity, Entropy and Mean.

Classification

Image classification is the technique of classifying or predicting the class of a particular object in an image based on certain rules. The aim of this process is to correctly detect the features in an image. Supervised and unsupervised methods are the two common methods in Classification. SVM is a supervised machine learning algorithm and is well suited for classification techniques. SVM means Support Vector Machine. The aim is to transform non-linear into linear transformation using SVM kernel function [5] [7]. In this work, we have used the linear kernel function for classification. SVM is made as the default choice for classifying brain tumour by the features selected with kernel class separatability. The confusion matrix denoting the terms True Positive, False Positive, True Negative and False Negative from the expected results and ground truth result is created for accuracy calculation.

$$\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN}$$

The whole process of classifying brain tumour image is distinguished into two stages namely training and testing. From the image dataset consists of 15 images, 10 images are chosen for training the classifiers and 5 images are chosen to test the performance of classifiers.

For training purpose, the feature extraction method Gray Level Cooccurrence Matrix (GLCM) is used. In testing stage, the statistical values of trained images are used for brain tumour classification.

From this image dataset, another set of brain tumour images is chosen for testing. Using the above specified method GLCM, statistical features are extracted for the testing images. From the set of trained and test values, the SVM classifier classifies the brain tumour with images as benign and malignant.

V. RESULTS AND DISCUSSION

For Segmentation, tumour detection method based on Threshold and K-means clustering techniques were proposed. Thresholding techniques segment the tumor area by its intensity value in MRI brain images. Otsu method is excellent for image which histogram is bimodal distribution and, in this technique, single or one threshold value is used for the full image. But in local thresholding technique, unique or specific threshold values is used for the partitioned sub images obtained from full image.

Kmeans clustering algorithm evaluates different pixels and groups the similar pixels together. Since Kmeans clustering is convenient for large datasets and it works well on spherical cluster and efficient to make change. Therefore, K-means clustering algorithm is a suitable method to segment brain MR images.

The goal of SVM algorithm is to find the hyperplane which distinguishes the data points. The dimension of this hyperplane is based upon the number of features. This technique is done on the basis of margin maximization principle. In the goal of achieving perfect generalization performance, it performs structural risk minimization. With SVM classifier it classifies the brain tumour images as Benign and Malignant as shown in Figure 7 and 8.

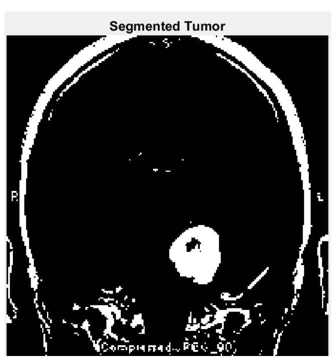

Figure 7. Image detected as benign tumour using SVM Classification.

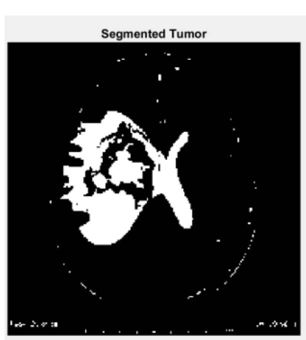

Figure 8. Image detected as malignant tumour using SVM Classification.

VI. CONCLUSION

There are different types of tumours. It may be benign or malignant. K-means clustering algorithm plays a significant role in extracting the tumour from the brain tumour image. The dataset consists of MRI (Magnetic Resonance Imaging) brain tumour images. The brain tumour images, used in this image processing techniques were taken from publicly available sources. The dataset was divided into training dataset and testing dataset.

In this paper, we have automated the analysing procedure for brain tumour detection through image processing techniques. All the steps for detecting brain tumour have been discussed starting from MRI image dataset, pre-processing to classification of the tumour using three segmentation techniques. Pre-processing involving operations like grayscale transformation and noise removal using median filter have been done. After the image quality improvement and noise reduction discussed here, segmentation methodology for MRI image of brain tumour has been used. The segmentation methods used include, Otsu binary segmentation, Local thresholding and K means clustering algorithm. Otsu method is excellent for image which histogram is bimodal distribution and, in this technique, single or one threshold value is used for the whole image.

In local thresholding technique, unique or specific threshold values is used for the partitioned sub images obtained from full image. K-means clustering algorithm evaluates different pixels and groups the similar pixels together. Since K-means clustering is convenient for large datasets and it works well on spherical cluster and efficient to make change, we conclude that K means is suitable method to segment MRI images. Feature extraction is a process of dimensionality reduction and is followed by segmentation. The extracted feature includes Contrast, Energy, Correlation, Homogeneity, Mean, Standard deviation, Entropy, Smoothness and Variance. Classification was done by using SVM. SVM classification method was able to detect the presence or absence of tumour, and if the presence of tumour was detected, it was able to determine whether the type is benign or malignant.

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