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Medical Image Analysis using Machine Learning Techniques

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Abstract— Image Processing has been a growing field for the biomedical images. MRI, CT scans and X-Ray are the different types ofimages used in this technique. All these techniques helps to identify even a minute deformity in the human body. The main purpose of medical image processing is to extract meaningful information from these images. MRI is the most reliable form of biomedical image available to us asit does not expose the human body to any sorts of harmful radiation. Once the MRI is obtained it can be processed, and the part of brain affected by tumor can be segmented. The complete process of detecting brain tumor from an MRI can be classified into four different categories: Pre-Processing, Segmentation,Feature Extraction and Tumor Detection. This survey involves analyzing and taking help of the research by other professionals and compiling it into one paper.

Keywords — *OpenCV, Image Processing, Active contour, Machine Learning, Segmentation, Feature Extraction*

I. INTRODUCTION

Brain is an organ that controls activities and is the most complex organ in the human body. Tumor is formed by non-uniform division of cells inside the human brain. Diagnosis of Brain tumor is very important for calculation of the suitable treatment of the tumor. Tumor basically refers to uncontrolled death and birth of new cells. A cell rapidly divides to form a new cell and non-uniformity in it causes harm to the normal functionality of the brain, and destroy the normal cells. Metastasis is a process in which non-uniform cell(lump) moves to the different parts of the body other than the brain. There are different types of the formation of the brain tumor. The most understandable classification is aggressive and non-aggressive tumor. Where, aggressive tumor indicates the cancerous and growing tumor and non-aggressive is non-cancerous tumor.

Brain tumor could be easily treated in a better way to prevent more damages to the brain, by detecting the type of tumor at the early stages. Brain tumor symptomsdepend upon the size of tumor, location and its type. Detection of tumor can be done by MRI, which is the one of the best biomedical imaging technique, used for detecting and modeling the tumor depends on the measurement of magnetic field vectors generated after an appropriate excitation of strong magnetic fields and radio frequency pulses in the nuclei of hydrogen atoms present in the water molecules of a patient's body. The conventional method for tumor detection in MRI image is human inspection which is a time consuming method and is not appropriate for large amount of data. Automated detection of brain tumor in MRI images is necessary as high accuracy is needed when dealing with human life.

In this paper, an efficient automated segmentation technique for brain MRI is proposed using machine learning algorithms. The supervised machine learning technique is used for detection of brain MR image.

The paper is organized in different sections as follows. In Section 2 literature survey is done. In Section 3, proposed method is described. In Section 4, experimental results are shown. Finally in Section 5, the conclusion of our work is discussed.

II. RELATED WORK

Joshi et al. [1] proposed brain tumor detection and classification system in MR images by first extracting the tumor portion from brain image, then extracting the texture features of the detected tumor using Gray Level Co-occurrence Matrix (GLCM) and then classified using neuro-fuzzy classifier. Sapra et al. [2] proposed image segmentation technique to detect brain tumor from MRI images and then Probabilistic Neural Network (PNN) is used for automated brain tumor classification in MRI scans. PNN system proposed handle the process of brain tumor classification more accurately. Natarajan et al. [3] proposed brain tumor detection method for MRI brain images. The MRI brain images are first pre-processed using median filter, then segmentation of image is done using threshold segmentation and morphological operations are applied and then finally, the tumor region is obtained using image subtraction technique. This approach gives the exact shape of tumor in MRI brain image. Rajeshwari and Sharmila [4] proposed pre-processing techniques which are used to improve the quality of MRI image before using it into an application. The average, median and wiener filters are used for noise removal and interpolation based Discrete Wavelet Transform (DWT) technique is used for resolution enhancement. The Peak Signal to Noise Ratio (PSNR) is used for evaluation of these techniques. George and Karnan [5] proposed MRI image enhancement technique based on Histogram Equalization and

Center Weighted Median (CWM) filter as they are used to enhance the MRI image more effectively. Suchita and Lalit [6] proposed unsupervised neural network learning technique for classification of brain MRI images. The MRI brain images are first pre-processed which include noise filtering, edge detection, then the tumor is extracted using segmentation. The texture features are extracted using Gray-Level Co-occurrence Matrix(GLCM) and then Self-Organizing Maps (SOM) are used to classify the brain as normal or abnormal brain, that is, whether it contain tumor or not.

III. THE PROPOSED METHOD

According toliterature survey, it was found that automated brain tumor detection is very necessary as high accuracy is needed when human life is involved. This technique involves segmentation and feature extraction using machine learning algorithm. In this paper, a system to automatically detect tumor using MR images is proposed as shown in figure 1.

A. Image Acquisition:

The MRI brain images are obtained are used as input to the pre-processing stage. The sample brain MR images are shown in fig 2.

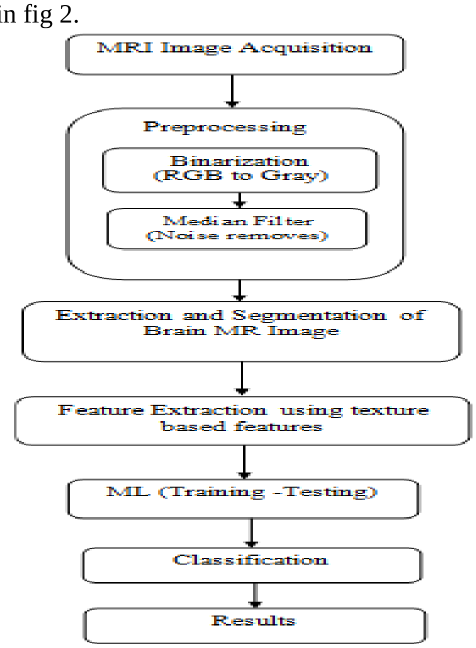


FIG 1. PROPOSED METHOD FOR BRAIN TUMOR DETECTION IN MR IMAGES

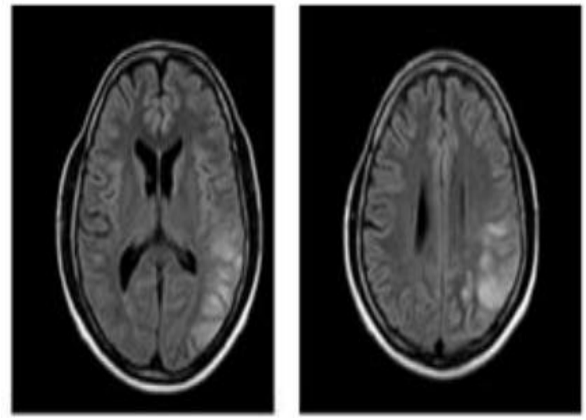


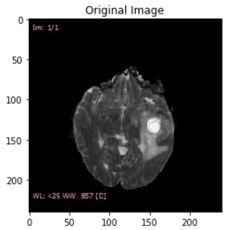
Fig 2: Sample MR images of brain

B. Pre-processing:

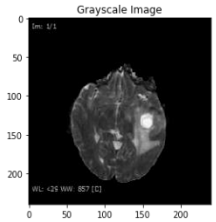
Pre-processing is needed as it provides improvement in image data which enhances some of the image features which are important for further processing. The pre-processing steps applied to MR image are as follows :
The RGB MR image is converted to gray scale image and then median filter is applied for noise removal from brain MR images as shown in fig. 3(b) for further processing as high accuracy is needed.

The edges are then detected from filtered image using canny edge detection as shown in fig. 3(c) which is needed for segmentation of the image.

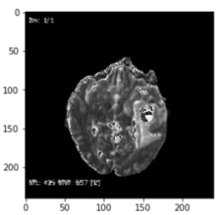
Then segmentation of MR image is done for finding the location of the tumor in the brain image as shown in fig. 3(d). Segmentation is the process of dividing an image into multiple segments and change details of image into something which is simple and easy to observe. The output of segmentation is a labeled image. In this image, many different objects present in the image will be identified having different pixel values, where all the pixels of firstobject will have value 1, all the pixels of second object will have value 2 and so on. The various pre-processing operations applied on brain MR image are shown in fig. 3.



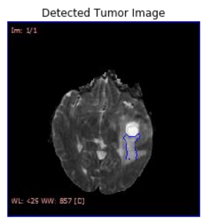
(a) Original Image



(b) Filtered Image



(c) Segmented Image



(d) Detected Tumor Image

C. Feature Extraction

When input to an algorithm is very large and redundant to be processed, it is transformed into reduced representative set of features called feature vector. Transformation of input data into set of features is called feature extraction. In this step, the important features needed for image classification are extracted. The segmented brain MR image is used and texture features are extracted from the segmented image which shows the texture property of the image. These features are extracted using Gray Level Co-occurrence Matrix (GLCM) as it is robust method with high performance. The GLCM texture feature extraction method is very competitive as using smaller number of gray levels shrinks the size of GLCM which reduces the computational cost of the algorithm and at the same time preserves the high classification rates. These GLCM features are used to distinguish between normal and abnormal brain. Texture contains some important information about surface structural arrangement. The textural features based on gray-tone spatial dependencies have a general applicability in image classification.

The GLCM texture features that are extracted are as follows:

(1) Mean (M). The mean of an image is calculated by adding all the pixel values of an image divided by the total number of pixels in an image.

$$M = \left(\frac{1}{m \times n}\right) \sum_{x=0}^{m-1} \sum_{y=0}^{n-1} f(x, y) .$$

(2) Standard Deviation (SD). The standard deviation is the second central moment describing probability distribution of an observed population and can serve as a measure of in-homogeneity. A higher value indicates better intensity level and high contrast of edges of an image.

(3) Energy : It gives a measure of textural uniformity, that is, measure of pixel pair repetitions.

$$\mathrm{E} = \sum_{i=0}^{N_g-1} \sum_{j=0}^{N_g-1} p(i,j)^2$$

(4) Contrast : It gives a measure of intensity contrast between a pixel and its neighbour over the whole image.

$$\mathrm{Con} = \sum_{n=0}^{N_g-1} n^2 \sum_{i=0}^{N_g-1} \sum_{j=0}^{N_g-1} p(i,j)^2$$

(5) Correlation : It gives a measure of how correlated a pixel to its neighbour over the whole image.

$$\mathrm{C} = \frac{1}{\sigma^x \sigma^y} \sum_{i=0}^{N_g-1} \sum_{j=0}^{N_g-1} (i,j) p(i,j)^2 - \mu_x \mu_y$$

Thus to detect whether the brain is affected by tumor or not , initially the MRI brain images are collected, pre-processing steps and segmentation are then applied. The segmented image is used for feature extraction and texture features are extracted using GLCM. The pre-processing and feature extraction steps are done using OpenCV tools.

IV. EXPERIMENTAL RESULTS

The experiment was carried out on dataset collected from expert radiologists, which included sample MR images of 40 patients. For the purpose of the analysis, initially we considered 22 images, all of which included were tumor-infected brain images. However, this dataset did not have any ground truth images. The second dataset consists of brain MR data obtained which is yet to be detected as tumor or no-tumor.

This dataset included a variety of slice thicknesses, noise levels, and levels of intensity non-uniformity. The images used for our analysis are mostly included T2-weighted modality with 1 mm slice thickness, 3% noise, and 20% intensity non-uniformity. In this dataset, 13 out of 44 images included are tumor-infected brain tissues.

$$\mathrm{SD}(\sigma) = \sqrt{\left(\frac{1}{m \times n}\right) \sum_{x=0}^{m-1} \sum_{y=0}^{n-1} \left(f(x, y) - M\right)^2}.$$

The last dataset collected from expert radiologists consisted of images of 15 patients with all modalities and it also had ground truth images that helped to compare the results of our method with the manual analysis of radiologists.

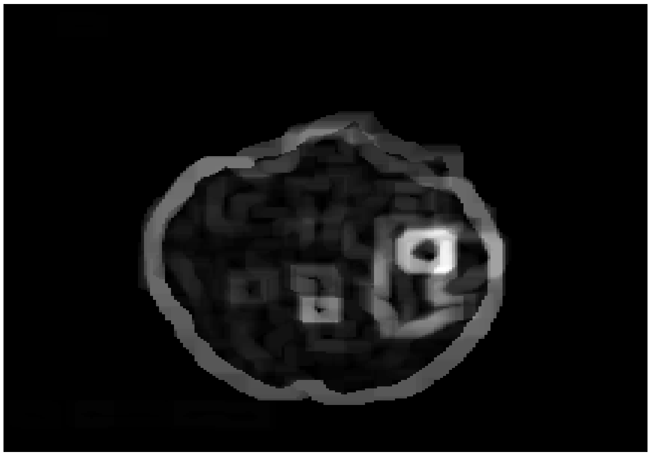


Fig.: Edge-detected brain tumor image

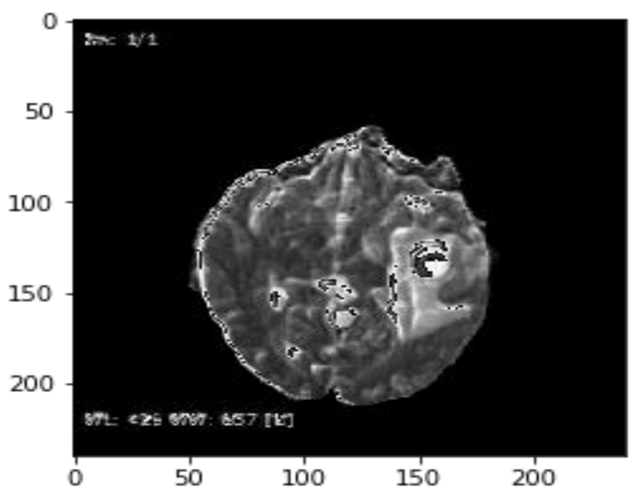


Fig.: Detected Tumor Image of the brain

GxGy

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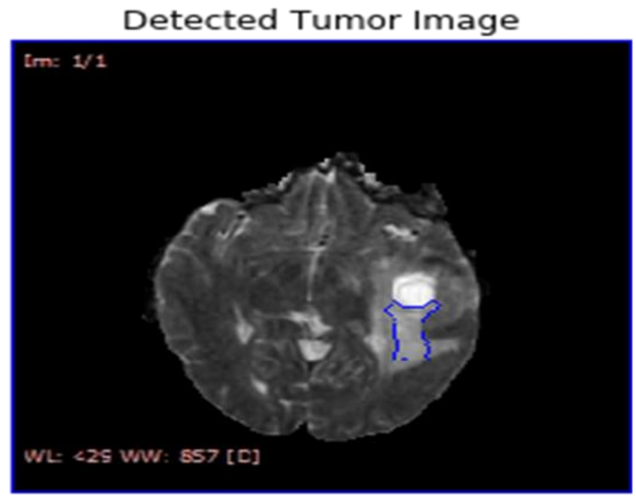
[[-1  0  1]        [[ 1  2  1]
 [-2  0  2]         [ 0  0  0]
 [-1  0  1]]        [-1 -2 -1]]
```



Edge-detection using 3*3 Sobel Filters

V. CONCLUSION AND FUTURE SCOPE

In this study, by using MRI brain images, we segmented brain tissues into normal tissues such as white matter, gray matter and tumor-infected tissues. Fifteen patients infected with a glial tumor, in benign and malignant stages, assisted in this study. Initially we used pre-processing to improve the signal-to-noise ratio and to eliminate the effect of unwanted noise such that we get the filtered image required for the tumor detection. In the next step, features are extracted from the filtered image to obtain the morphological image and the active contours. Finally the tumor is detected based on the different feature extraction techniques used in this study.

In this study, we used OpenCV which provides simple and useful ways to read and write images. This technique also allows us to analyse the image by means of different patterns.

From the experimental results performed on the different images, it is clear that the analysis for the brain tumor detection is fast and accurate when compared with the manual detection performed by radiologists or clinical experts.

In the future work, to improve the detection and get the accuracy of the classification of the present work, more than one classifier and feature selection techniques can be combined to get a better result.

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