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Automated Brain Tumor Identification (ABTI) Using Image Processing

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Abstract - *The collection or mass of abnormal cells found in the brain is known as a tumor. It can be cancerous (malignant) or non-cancerous (benign). It can either start in the brain or can spread to the brain by cancer elsewhere. Every year, brain tumors are one of the major causes of death in humans. So the detection at an early stage using MRI or CT scans can prevent the tumor turning cancerous. This paper focuses on detecting, localizing and highlighting the tumor from the MRI scan of the patient based on the proposed methodology. It works as a second-hand help to doctors.*

This methodology includes five main stages ie., pre-processing, segmentation, edge detection, feature extraction, identification and classification. In pre-processing, the MRI image is converted to a gray-scale image and a median filter is used to remove noise, if present. The next stage is segmentation which divides the image into regions based on similar attributes. This is done using OTSU thresholding based segmentation technique and is then clustered using the K-means clustering algorithm. Then the next stage is edge detection; the Canny Edge Detection algorithm is used for the same. This is followed by feature extraction which is the extraction of required features within the edge to identify the tumor. The final stage is identification and classification which identifies the tumor if it is present in the image and classifies the case into either 'normal' or 'abnormal'. The software used for this project is MATLAB.

Keywords: *Segmentation, MRI, Median filter, Canny Edge Detection, OTSU Thresholding based segmentation, K-means clustering, Tumor.*

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I. INTRODUCTION

Brain Tumor is the presence of abnormal cells in the brain[1]. There can be two instances; one being such that the cells overgrow and form a lump or the uncontrollable growth of cells. The former is non-cancerous or benign and the latter is cancerous or malignant. Most benign tumors are not necessarily harmful unless it proves a threat such as squeezing nerves or blood vessels resulting in pain or overproduction of hormones. Malignant tumors consist of cancerous cells which can most likely return after removal unlike benign. These cells can grow quickly and uncontrollably and spread to other parts of the body and threaten life. This process of quick-spreading is called metastasis. The common symptoms of brain tumor include headaches, nauseas, seizures, drowsiness, memory and personality problems and changes. Because brain tumors can be life-threatening, a patient's diagnosis and treatment are critical.

Tumor tissue is analysed using microscopic analysis such as biopsy or electronic strategies such as MRI and CT scans, Ultrasound. Among all the electronic strategies Magnetic Resonance Imaging (MRI) is the most popular strategy in which medical imaging technology is used to create images of the anatomy and physiological processes of the body. Strong magnetic fields, magnetic field gradients, and radio waves are used in MRI scanners to create pictures of the body's organs. [11,12]

In this proposed approach, the MRI images were incorporated for brain tumor detection and would be processed under the proposed algorithm then the output image would contain the localized tumor highlighting its edge; if the tumor is detected. The result would be ‘abnormal’ for images containing tumor and ‘normal’ for images free of tumor.

II. RELATED WORKS

A strategy for detecting and localising brain tumors from patients' MRI scans was proposed by [2]. Pre-processing, edge detection (Sobel, Prewitt, and Canny edges), and segmentation are the three stages of the proposed method. Finally, the tumor region was identified using k-means clustering. However, in their proposed method, the output image contains more regions than the tumor region, which may cause some misunderstanding.

The research work by [3] proposed a method for locating a tumor with four steps. The wavelet filter is used to remove the noise in the image in the first step. As an initial method for segmentation, the watershed algorithm is used to MRI image pixels in the second stage. Then, using the fuzzy clustering technique, a merging operation is performed on the segmented area. Finally, the k-NN classifier is used to apply the re-segmentation process to those regions that are not completely partitioned.

The research [4] offered an automated method that involves initial enhancement to reduce gray-scale colour fluctuations. To aid improved segmentation, a filter operation was employed to remove as much unnecessary noise as feasible. Because the images in this study were grayscale, threshold-based OTSU segmentation was employed instead of colour segmentation. Finally, predefined information that was used to establish the study's areas of focus

The method proposed by [5] used k-means clustering to segment and cluster MRI images of the brain, followed by morphological filtering for miss clustered tumors.

According to the related works, segmentation is the most important aspect of brain tumor analysis. The success of segmentation determines the detection of the tumor region. Because our study included grayscale images, we used threshold-based OTSU segmentation and k means clustering rather than colour segmentation.

III. METHODOLOGY

Image Processing is the process of manipulation of digital images using a digital computer with the help of suitable algorithms. The input is the unprocessed or the raw digital image and it is processed using efficient algorithms and gives the processed image with the necessary result as output.

Magnetic Resonance Imaging (MRI) is a type of electronic scanning method that makes the use of strong magnetic fields and radio waves to produce a defined image of the interior of the body. It can be used to scan any part of the body such as the brain, spinal cord, heart, blood vessels, bones, joints and internal organs like liver and other abdominal organs.

Segmentation in image processing is dividing or partitioning the image into different regions based on some property. It is used to change the representation of an image into an analyzable form. In segmentation each pixel of an image is assigned a label and all the pixels under a specific label share the same characteristics.

OTSU Thresholding based segmentation is used to perform automatic thresholding of the image. In this method all the image pixels are divided into two classes; one for white (foreground) and one for black (background) and the dataset is divided into clusters for further processing. Then the threshold which minimizes the intra-class variance or which maximizes the inter-class variance is chosen.

K-Means Clustering is a method of vector quantization in which n observations would be divided into k clusters. A cluster contains a centroid or mean and all the elements present in the cluster would be within the euclidean distance from the centroid. The elements within the cluster would be highly similar (low intra-class variance) and elements within two clusters would be highly dissimilar (high inter-class variance).

Median Filter is a non-linear filtering technique commonly used in biomedical fields. It is used to remove noises like salt and pepper also known as impulse noise which occur frequently in medical scan images due to the disturbances caused in the image signal.

Canny Edge Detection is used to detect edges in an image. This algorithm uses methods like double thresholding to find the potential edges and tracks edges by hysteresis.

IV. PROPOSED SYSTEM

This proposed approach contains five main steps ie., pre-processing, segmentation, edge detection, feature extraction and identification and classification.

Algorithm for this proposed system

Step1: MRI image of the human brain is given as input.
Step2: Image is converted into rgb-grayscale image.
Step3: Image is enhanced
Step4: Noise is removed from the image using the Median filter.
Step5: OTSU Thresholding based segmentation is done and K-Means is applied.
Step6: Edge Detection is done using Canny Edge.
Step7: Features required is extracted
Step8: Identification of tumor and classification into normal and abnormal is done.
Step9: Superimposed image is returned if tumor else no change in the input image.

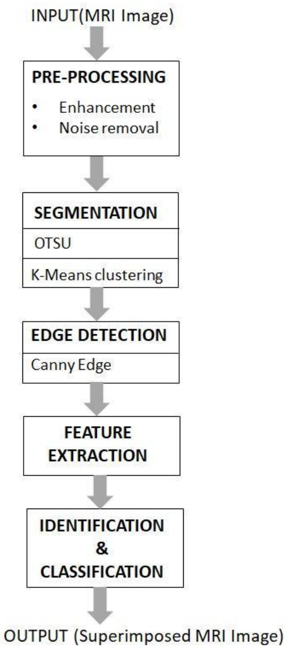

Figure 1

The above steps are elaborate below.

A. Pre-processing

A brain tumor dataset [6] has been used in the implementation of the proposed method. It is the initial stage and it contains conversion of the MRI image into grayscale image. After the conversion, the image is enhanced. In enhancement, maps the intensity values in grayscale image to new values where this operation increases the contrast of the output image. Median Filter is then used for noise removal. The image is processed with a filter to improve the smoothness, sharpness, and edge enhancement. In our proposed strategy, the median filter has been used instead of other filters such as the mean and Gaussian filters. This is because the mean filter reduces noise better but does not retain edges, whereas the Gaussian filter keeps edges but blurs the image [7]. When compared to mean and Gaussian filters, the median filter is more successful because it reduces noise at a reasonable level while keeping the edges. Furthermore, it produces a less blurry image than the Gaussian filter.

B. Segmentation

Segmentation separates an image into sections based on features that are comparable. OTSU Thresholding based segmentation is used to find the threshold value for the input image and it segments the image and is also used to do the binary transformation of the image.

Clustering is the separation of an image into numerous divisions for simpler analysis and comprehensive study of the image's important parts. Segmentation of image is done in such a way that each segment has some common property. The full image is constructed from a collection of segmented images. The k-means algorithm is used in the suggested method to accurately predict the brain tumor sites.

C. Edge detection

The corresponding edge is determined using Canny Edge Detection Algorithm if a tumor is localized.

D. Feature extraction

For the edge detected, features such as area, perimeter and solidity are extracted. Then roundness and diameter are calculated from the above result.

Various shape criterias are essential to diagnose the brain tumor, according to existing study work [8] and medical expert guidance. For each shape in the image, the MATLAB function region-propos returns a list of characteristics. To detect the ROI (region of interest), our study examined several criteria such as area [9], perimeter, circularity [10] (roundness and diameter) and solidity [10].

$$Roundness = \frac{4 \times \pi \times Area}{(perimeter)^2}$$

$$Diameters = \sqrt{\frac{4 \times Area}{\pi}}$$

E. Identification and Classification.

Here the cropped image (ROI) undergoes various processes and the end result will be recognized from the image. This is superimposed to the output.

V. EXPERIMENTAL RESULTS

A. Experimental Outcomes

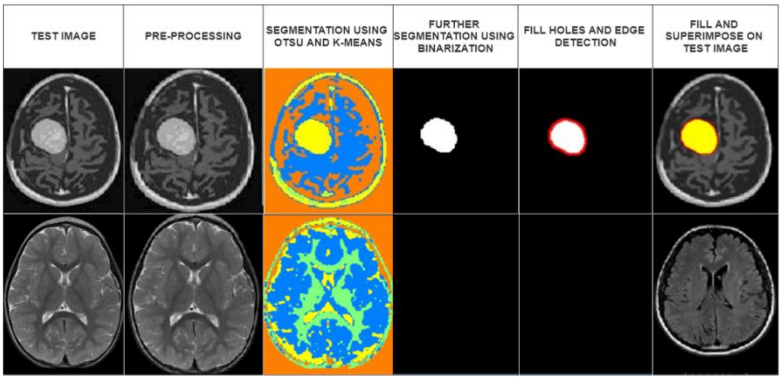

Table 1

Table 1 depicts the various experimental outcomes of this study's recommended strategy. It shows two photos of brain tumors at every stage.

The input images are listed in the first column. To improve the image contrast in the second column, pre-processing and filtering operations were used. The image, after OTSU thresholding and K-means segmentation is shown in the third column. The image after binarization, which will be ROI if present, is displayed in the fourth column. If there are any holes, they are filled, and the Canny Edge Detection Algorithm is used to locate the edge, as seen in the fifth column. Finally, the tumor is identified and placed on the test picture. In the command window the output is presented, as illustrated in Fig.2 .

Figure 2

VI. CONCLUSION

The identification of a brain tumor manually is not only time consuming but also tedious, whereas an automated technique requires less time. In comparison to other current methodologies, the proposed methodology in this research study saves time and improves accuracy. Because early diagnosis of a tumor is critical for a brain tumor patient, this study will aid pathologists in detecting brain tumors more rapidly and accurately.

Because of the complicated structure of brain tumors, indistinct borders, and external influences such as noise, inferring tumor and edoema regions from brain magnetic resonance imaging (MRI) data remains difficult. An effective hybrid clustering approach may be utilised to reduce noise sensitivity and increase segmentation stability. Then there's a probability that the accuracy rate may rise in the future.

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