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Performance Analysis of Image Thresholding Methods on Brain Cancer MRI for Segmentation

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***Abstract*—Medical image processing is most important and challenging field now a days. Image preprocessing of brain MRI and its analysis is act of examining images for identifying objects and analyzing their significance. In medical image processing early detection and analysis of brain cancer is most difficult and time consuming task. In medical field image processing techniques are used for improving early detection and treatment stages, especially in various cancers. Image segmentations refer to process of partitioning the image into multiple segments for locating objects and boundaries in image. Image thresholding is one of the techniques for image segmentation to binarize the image based on pixel intensities as it partitions the image into two groups of pixels. In this proposed work three methods of image thresholding has been implemented. Three techniques are simple thresholding, adaptive thresholding and Otsu's thresholding are applied specifically on brain cancer MRI image. The implementation work is done by using python open CV library. To check the performance of each image thresholding technique, black pixel and white pixel ratio has been calculated.**

***Index Terms*— Image PreProcessing, Image Thresholding, Brain Cancer, Image Segmentation, MRI(Magnetic Resonance Imaging).**

I. INTRODUCTION

Human Brain is most vital part of human body and it is having complex structure. Brain cancer is a very serious type of malignancy as there is an uncontrolled growth of cancer cells in the brain. Not all brain tumors are malignant (cancerous). Some types of brain tumors are benign(non-cancerous).

Medical imaging [1]is the technique and process of creating visual representations of the interior of a body for clinical analysis and medical intervention, as well as visual representation of the function of some organs or tissues. Medical imaging seeks to reveal internal structures hidden by the skin and bones, as well as to diagnose and treat disease. There are various modalities who are involved in this technology as Digitized X-ray, Computed Tomography (CT),Magnetic Resonance Imaging (MRI) ,Ultrasound (US),Positron Emission Tomography (PET) ,Nuclear Medicine (NM),Radiation Therapy.

It is important to have a good representation of the input data, i.e. a good set of features that produces a feature space in which an algorithm can use its bias in order to learn.

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MRI(Magnetic Resonance Imaging) [2] is a medical scanning test that has strong magnets to generate magnetic field and radio waves for generating two or three dimensional image of various body organs and uses computer to read the taken image. In brain tumor diagnosis, doctors integrate their medical domain knowledge and brain magnetic resonance imaging (MRI) scans to obtain the characteristics of brain tumors and decide for further treatment options.

Medical image processing can be carried out in four stages. The first stage is to use a set of images collected from the patients to be investigated. The second stage is to apply image enhancement or preprocessing techniques to obtained better quality images. The third stage is to apply image segmentation methods which are the most important part of image processing procedures. The last stage is to extract the necessary features from enhanced and segmented images which give important information of normality or abnormality of images.[3]

Image segmentation refers to class of algorithm that partition the image into different segments or group of pixels. There are different types of image segmentation techniques like Thresholding, Clustering, Edge based Segmentation, Region base segmentation, Artificial Neural network based segmentation etc. Image segmentation is used for extraction of abnormal tumor portion which is essential for volumetric analysis. This volumetric analysis determines the effect of the treatment on the patient which can be judged from the extracted size and shape of the abnormal portion.

MRI Segmentation is very challenging and difficult task because of variety of image shapes, location and intensity. Also manual segmentation of brain tumor is tedious job and may provide inaccurate results. Therefore, there is a need for computer aided brain tumor detection and segmentation from brain MR images to overcome the problems involved in the manual segmentation. Various techniques of image processing when combined with algorithms of image segmentation for accurate classification and prediction of brain cancer.

Image thresholding is the one of the kind of image segmentation technique as it partitions the image into two groups of pixels, white for foreground and black for background. In this paper three types of image thresholding techniques has been implemented. First is simple thresholding in which a global value of threshold is used. Second Adaptive thresholding in this the threshold value is calculated for smaller regions and third Otsu thresholding in this technique value of the threshold isn't chosen but is determined automatically. A binary image has been generated as an output of thresholding that can be used for further image processing. For each technique black pixel and white pixel ratio is calculated and the method with less black pixel ratio is best thresholding technique.

II. Literature Studies

Medical Imaging is the technique of capturing medical data from a patient by passing any medium, be it light rays, or other high precision rays .The procedure can be invasive or noninvasive. There are various modalities like Digitized X-ray, Computed Tomography (CT),Magnetic Resonance Imaging (MRI) ,Ultrasound (US),Positron Emission Tomography (PET) ,Nuclear Medicine (NM),Radiation Therapy.[1]

Brain tumor is the abnormal growth of cancerous cells in Brain. In medical field, segmentation of brain regions and detection of brain tumor are very challenging tasks because of its complex structure. Primary diagnosis of brain tumors is extremely significant, because it can save lives. Accurate segmentation of brain tumors is also important, as it can help medical personnel in the planning of treatment and intervention. Manual segmentation of tumors requires a long period of time, even for a qualified specialist. MRI images are affected by noises such as Rician, Gaussian, salt and pepper and so on. Noise removal is done with median filter and wiener filter to enhance the MRI image .Finally image segmentation is performed using k-means clustering.[2]

According to the World Health Organization and American Brain Tumor Association, the most common grading system uses a scale from grade I to grade IV to classify benign and malignant tumor types. On that scale, benign tumors fall under grade I and II glioma and malignant tumors fall under grade III and IV glioma.The grade I and II glioma are also called low-grade tumor type and possess a slow growth, whereas grade III and IV are called high-grade tumor types and possess a rapid growth of tumors.[3][4]

Image thresholding is one of the techniques for image segmentation. This technique can be described as:

$T = T[x, y, p(x, y), f(x, y)]$ [3]

T is the threshold value. x and y are the coordinates of the threshold value. $p(x,y)$ and $f(x,y)$ are the gray level pixels of the image

MRI is tested as a highly flexible, harmless and a recent medical imaging methodology for investigation of irregular changes in tissues and organs. Many techniques have been proposed for classification of brain tumors in MR images, most notably, fuzzy clustering means (FCM), support vector machine (SVM), artificial neural network (ANN), knowledge-based techniques, and expectation-maximization (EM) algorithm technique which

are some of the popular techniques used for region based segmentation and so to extract the important information from the medical imaging modalities. In this authors have implemented morphological operations, pixel subtraction, threshold based segmentation and image filtering techniques have been used also they have obtained clear images of the skull, brain and the tumor [4].
The primary task of pre-processing 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. In addition, pre-processing 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 [4].
Pre-processing is the first step in any data-driven study is to pre-process the raw images. Pre-processing removes noise by ensuring there is a degree of parity among all the images that in turn make the following segmentation and feature extraction steps more effective. This involves performing operations to remove artifacts, modify image resolution, and address contrast differences that arise from different acquisition hardware and parameters [5].
In the pre-processing step, both the mean filter and the median filter can be used to remove noise from an image. According to the outputs of the segmentation step, marker-controlled watershed segmentation approach has higher accuracy and better quality than thresholding approach. After segmentation of image, morphological operation is used to get individual brain and to eliminate unnecessary parts [6].
Thresholding is a simple and effective region segmentation method, in which the objects of the image are classified by comparing their intensities with one or more intensity thresholds. These thresholds can be either global or local. If the histogram of an image expresses a bimodal pattern, the object can be separated from the background in the image by a single threshold called global thresholding. However, if the image contains more than two types of regions, corresponding to different objects, the segmentation must be carried out using local thresholding. The image may be segmented by applying several individual thresholds or by using a multi thresholding technique [7].
In brain tumor detection is image pre-processing, the median filter and by using diagonal, anti diagonal masks segmented images get pre-processed and skull masking is done. After skull masking fatty tissues and other unwanted details get smoothen. Pre-processed image is segmented with the K-Mean segmentation [8].
In paper [9] authors have used a technique for identifying brain tumor from MRI images and MATLAB is been used for the design the proposed system, to make the design user friendly a GUI is been developed, the results found are very good in terms of accuracy and time delay.

III. PROPOSED APPROACH

There is a need to develop a system which is used to segment, analyse and predict brain cancer by using various image modalities. Proposed work is focused on implementing and applying various image thresholding techniques on Brain Cancer MRI Images. As in medical domain image pre-processing as it is a primary task to improve quality of MR images. These pre-processed images can be further processed by various algorithms. Pre-processing helps in improving 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.

Thresholding is a technique which is the assignment of pixel values in relation to the threshold value provided. In thresholding, each pixel value is compared with the threshold value. If the pixel value is smaller than the threshold, it is set to 0, otherwise, it is set to a maximum value (generally 255).

The threshold image g(x,y) can be defined as:

$$g(x,y) = \begin{cases} 1 \text{ f } (x, y) > T \\ 0 \text{ f}(x, y) \leq T \end{cases}$$

Where, g(x, y) = output image , f(x, y) = input image and T = threshold value.

This paper is focusing on the implementation of various image thresholding techniques using python OpenCV library on Brain Cancer MRI images. Figure 1 presents the steps that are followed for image thresholding and skull scripting. Skull Stripping is used to remove non brain tissues in brain image and further it is used for effective analysis of brain cancer MRI images. This paper represents the output of brain cancer MRI images after

applying all image thresholding techniques that are simple threshold, adaptive threshold and OTSU method threshold using python libraries. The input to thresholding algorithm is usually a grayscale image. The output is a binary image. For applying algorithms on data , BRATS (multimodal images of brain tumor Segmentation Benchmark) data sets have been used. Initially the brain cancer MRI image has been read using python libraries and it is converted into gray scale by using BGR2GRAY method of python open cv library. After conversion of image into gray scale extraction of the mask is done by preparing histogram of various intensities. Once the mask is extracted three techniques (simple, adaptive, OTSU) are applied to analyze the output by calculating black pixel ratio and white pixel ratio.

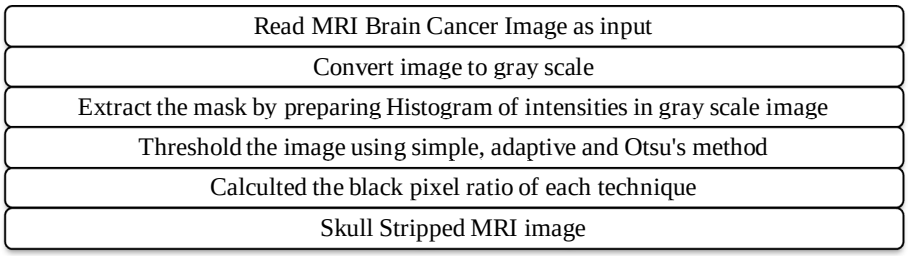

Figure 1 Proposed Methodology

Three thresholding techniques, first Simple Thresholding. Second Adaptive Thresholding and third using OTSU thresholding on brain cancer MRI image has been implemented. Threshold function is predefined in open cv library of python for image thresholding. It accepts gray scale image, threshold value, max value that is to be given if pixel value is more than the threshold value and type of threshold to be used. Once the threshold image is retrieved then black pixel ratio and white pixel ration are calculated using the formula.
Black pixel ratio = total number of black pixel in image/ size of image.
White pixel ratio = total number of white pixel in image/ size of image

A. Simple Thresholding

Simple thresholding operation the pixels whose values are greater than the specified threshold value, are assigned with a standard value. In this technique the threshold value is global, i.e., it is same for all the pixels in the image. If the pixel value is smaller than the specified threshold value , it is set to 0, otherwise, it is set to a maximum value. Figure 2 represents original brain MRI image which is read through python predefined library function. A simple thresholding is having various styles like THRESH_BINARY, THRESH_BINARY_INVERTED, THRESH_TRUCNC , THRESH_TOZERO, THRESH_TOZERO_INVERTED.
As shown in figure 2 simple thresholding is applied on brain cancer MRI. All the styles of simple thresholding techniques have been implemented on Brain cancer MRI image. First technique is THRESH_BINARY it means if pixel intensity is greater than the set threshold, value set to 255, else set to 0 (black). THRESH_BINARY_INVERTED is exactly opposite to THRESH_BINARY. In case of THRESH_TRUCNC If pixel intensity value is greater than threshold, it is truncated to the threshold. The pixel values are set to be the same as the threshold. All other values remain the same. THRESH_TO_ZERO indicates Pixel intensity is set to 0, for all the pixels intensity, less than the threshold value. THRESH_TOZERO_INV indicates Inverted or Opposite case of THRESH_TOZERO.

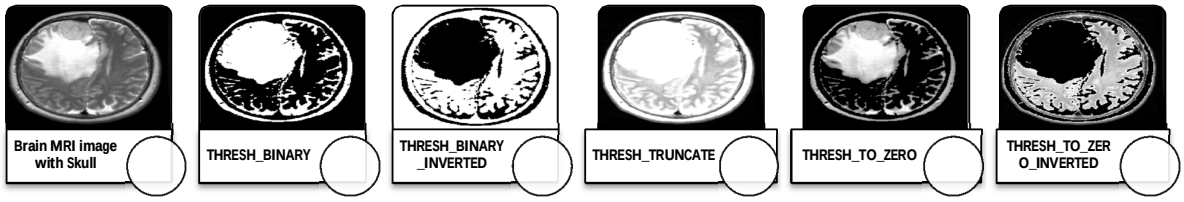

Figure 2 Simple Thresholding Techniques

Table I represents the calculated black and white pixel ratio in various techniques of simple thresholding

TABLE I BLACK AND WHITE PIXEL RATIO SIMPLE THRESHOLDING

Simple Thresholding Technique	Black Pixel Ratio	White Pixel Ratio
THRESH_BINARY	0.68	0.31
THRESH_BINARY_INVERTED	0.31	0.68
THRESH_TRUNCATE	0.11	0.0
THRESH_TO_ZERO	0.68	0.0049
THRESH_TO_ZERO_INVERTED	0.43	0.0

B. Adaptive Thresholding

Adaptive thresholding is the method where the threshold value is calculated for smaller regions and therefore, there will be different threshold values for different regions. This leads to different threshold values for different regions with respect to the change in lighting. There are two types of adaptive thresholding, First ADAPTIVE_THRESHOLD_MEAN and ADAPTIVE_THRESHOLD_GAUSSIAN.In the first type threshold value is the mean of neighbourhood area and in second technique threshold value is the weighted sum of neighbourhood values where weights are a Gaussian window. Figure 3 represents adaptive thresholding on brain cancer MRI image and it depicts the output of both the techniques (THRESH_MEAN and THRESH_GAUSSIAN).

Figure 3 Adaptive Thresholding Technique

Table II represents the calculated black and white pixel ratio in various techniques of adaptive thresholding.

TABLE II. BLACK AND WHITE PIXEL RATIO ADAPTIVE THRESHOLD

Adaptive Thresholding Technique	Black Pixel Ratio	White Pixel Ratio
Adaptive Mean	0.38	0.61
Adaptive Gaussian	0.52	0.47

C. Otsu's Thresholding

Otsu's thresholding chooses the threshold to minimize the interclass variance of the threshold black and white pixels. A value of the threshold isn't chosen but is determined automatically. This method involves iterating through all the possible threshold values and calculating a measure of spread for the pixel levels each side of the threshold, i.e. the pixels that either falls in foreground or background. It automatically calculates a threshold value from image histogram for a bimodal image. Bimodal image is an image whose histogram has two peaks or two distinct image values. Figure 4 represents the output of OTSU thresholding technique applied on Brain cancer MRI image. Steps that are followed in proposed implementation is to read the image, process the image, obtain the histogram and computed the threshold value. Replaced the image pixels into white in those regions where saturation is greater than T and replace the image pixels into black in regions opposite to it this process is called as Image Binarization. After Image Binarization, Connected Components are analysed means Connected pixels are set of pixels which are not divided by image boundary. After Connected Component analysis the extracted result may contain small amount of noise or some disturbance. So to eliminate them and improve the accuracy of the results, the extracted results are processed by the various operations of mathematical morphology like opening, closing, dilation and erosion. In this implementation work closing transformation has been applied as shown in figure 4.

Table 3 represents the calculated black and white pixel ratio in OTSU thresholding technique.

TABLE III BLACK AND WHITE PIXEL RATIO OTSU TECHNIQUE

OTSU Thresholding Technique	Black Pixel Ratio	White Pixel Ratio
Threshold OTSU	0.41	0.58

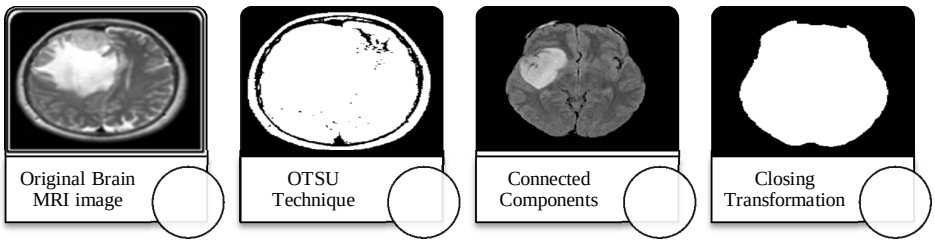

Figure 4 OTSU Thresholding

IV. CONCLUSION

In this paper brain cancer MRI image is considered for detection and extraction of brain cancer region by applying one of the techniques of image segmentation that is image thresholding. Skull is stripped from brain cancer MRI image for further image analysis, and it is required for the effective examination of brain tumor from the MR images. Image Thresholding is used to binarize the image based on pixel intensities. Various image thresholding techniques like simple, Adaptive and OTSU's techniques are implemented using python opencv library. The input to all image thresholding algorithms is Brain Cancer MRI gray scale image and a threshold value. The output is a binary image. Using a global threshold value (Simple Thresholding) may not be good choice where image has different lighting conditions in different areas. So, in that case, adaptive thresholding has been implemented by calculating the threshold for small regions of the image to get different thresholds for different regions of the same image and it gives better results for images with varying light conditions. Finally the OTSU threshold technique is applied that automatically calculated a threshold value from image histogram for a bimodal image. Otsu's method exhibits the relatively good performance by applying connected components and closing transformation. Black pixel ratio and white pixel ratio has been calculated for each technique, the OTSU method with less Black Pixel Ratio is best thresholding technique. The black pixel and white pixel ratio of each technique is calculated and represented by table1,table 2 and table 3 of this paper out of which OTSU method is generating less black pixel ratio. All these image thresholding techniques are applied and implemented using python for performing better analysis on medical images specifically brain cancer MRI. In future other image segmentation techniques can be implemented for better analysis of image.

REFERENCE

[1] R. R. Meenatchi Apama and P. Shanmugavadivu, "A literature review on medical imaging transfer," Proc. Int. Conf. IoT Soc. Mobile, Anal. Cloud, I-SMAC 2017, pp. 284–288, 2017, doi: 10.1109/I-SMAC.2017.8058356.

[2] A. Min and Z. M. Kyu, "MRI images enhancement and tumor segmentation for brain," Parallel Distrib. Comput. Appl. Technol. PDCAT Proc., vol. 2017-Decem, pp. 270–275, 2018, doi: 10.1109/PDCAT.2017.00051.

[3] U. Ilhan and A. Ilhan, "Brain tumor segmentation based on a new threshold approach," Procedia Comput. Sci., vol. 120, pp. 580–587, 2017, doi: 10.1016/j.procs.2017.11.282.

[4] V. Vadmal, G. Junno, C. Badve, W. Huang, K. A. Waite, and J. S. Barnholtz-Sloan, "MRI image analysis methods and applications: an algorithmic perspective using brain tumors as an exemplar," Neuro-Oncology Adv., vol. 2, no. 1, pp. 1–13, 2020, doi: 10.1093/noajnl/vdaa049.

[5] N. B. Bahadure, A. K. Ray, and H. P. Thethi, "Image Analysis for MRI Based Brain Tumor Detection and Feature Extraction Using Biologically Inspired BWT and SVM," Int. J. Biomed. Imaging, vol. 2017, 2017, doi: 10.1155/2017/9749108.

[6] V. Prema, M. Sivasubramanian, and S. Meenakshi, "Brain Cancer Feature Extraction Using Otsu ' S Thresholding Segmentation," Int. J. Comput. Appl., vol. 6, no. 3, pp. 21–29, 2016.

[7] N. Gordillo, E. Montseny, and P. Sobrevilla, "State of the art survey on MRI brain tumor segmentation," Magn. Reson. Imaging, vol. 31, no. 8, pp. 1426–1438, 2013, doi: 10.1016/j.mri.2013.05.002.

[8] S. R. Telrandhe, A. Pimpalkar, and A. Kendhe, "Detection of brain tumor from MRI images by using segmentation & SVM," IEEE WCTFTR 2016 - Proc. 2016 World Conf. Futur. Trends Res. Innov. Soc. Welf., 2016, doi: 10.1109/STARTUP.2016.7583949.

[9] S. Patel and D. Rao, "Brain Tumor Detection in MRI Images With New Multiple Thresholding," vol. 7, no. 6, pp. 34–39, 2017.