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STATISTICAL ANALYSIS OF SEGMENTATION TECHNIQUES FOR BRAIN TUMOR DETECTION

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Abstract- **Image segmentation is the fundamental step in medical image analysis. Segmentation is a procedure to separate similar portions of images showing resemblance in different features such as color, intensity, or texture. Grayscale images are mostly used for the segmentation of medical images. Tumors are commonly stated as the abnormal growth of tissues and the brain tumor is a diseased part in the body tissues that is an abnormal mass in which growth rate of cells is irrepressible. The mortality rate of people has raised over the past years due to brain tumor, hence this area has gained the attention of researchers. Automatic detection of brain tumor is a challenging task because it involves pathology, functional physics of MRI along with intensity and shape analysis of MR image, because tumor shape, size, location and intensity vary for each infected case. In this work, a comparison between Threshold segmentation, K means clustering, Watershed segmentation and Level set-based segmentation methods are performed to detect the tumor region of the brain. Statistical and Visual analysis is performed to figure out the best method. This research could help clinicians in surgical planning, treatment planning and accurately segmenting the tumor part with the most accurate method.**

Keywords – Brain tumor detection, Image segmentation, Threshold segmentation, K means clustering, Watershed segmentation, Level set segmentation

I. INTRODUCTION

Image segmentation is the fundamental step in medical image analysis. Segmentation is a procedure to separate similar portions of images showing resemblance in different features such as color, intensity, or texture [1]. Grayscale images are mostly used for the segmentation of medical images.

Tumors are commonly stated as the abnormal growth of tissues [2] and the brain tumor is a diseased part in the body tissues that is an abnormal mass in which growth rate of cells is irrepressible [3]. The mortality rate of people has raised over the past years due to brain tumor, hence this area has gained the attention of researchers. Commonly a tumor could be benign or malignant. Benign tumors are those tumors that remain within the boundaries of the brain, whereas the malignant tumors could extend beyond the brain and affect other parts of the body. These kinds of tumors may not be treated because of their aggressive nature. Now a days imaging is playing a vital role in diagnosis of the brain tumor in early stages before they become intractable, thus saving many lives. Different techniques have been developed to detect the tumors, like CT, MRI, EEG (electroencephalography) etc. The MR imaging method is the best due to its higher resolution and enhanced quality [4]. Automatic detection of brain tumor is a challenging task because it involves pathology, functional physics of MRI along with intensity and shape analysis of MR image, because tumor shape, size, location and intensity vary for each infected case [5].

Image segmentation algorithms are based on gray-level values of the pixels, sudden changes in the gray-level and similarity between pixels regions are the basis for segmentation of an image [6]. Various methods have been proposed for the segmentation of brain tumor from MR images, Baidya Nath Saha et.al [7] presented a bounding box method using symmetry to segment out tumors from brain MR images, Knowledge based techniques presented by Matthew C. Clark et.al [8] describe and compare results based on supervised and unsupervised clustering. C.L. Biji et.al [9] proposed fuzzy thresholding technique for brain tumor segmentation. Jianping Fan et.al [10] proposed a

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seeded region growing method in which seed selection and pixel labeling problem are addressed. Yu-len huang and Dar-ren chen [11] proposed segmentation based on a Watershed method for identifying the breast tumors. Nelly Gordillo et.al. [12], presented a review of the most relevant brain tumor segmentation methods. According to [12] in medical image, semi-automated and fully automated segmentation methods have gained the importance due to accuracy in identification, but it's a fact that the end systems are used by the physicians therefore there is a surprising lack of compatibility between large computer vision based frameworks and the low-level methods employed for segmentation. The other reason is that these approaches are still not capable to gain acceptance among pathologist for everyday clinical tasks due to not having any standardized procedures. Therefore, these approaches need to be compared with real world medical issues to address problems of segmentation with best approaches.

In this work, a comparison between Threshold segmentation, K means clustering, Watershed segmentation and Level set-based segmentation methods are performed to detect the tumor region of the brain. Statistical and Visual analysis is performed to figure out the best method. This research could help clinicians in surgical planning, treatment planning and accurately segmenting the tumor part with the most accurate method.

II. IMPLEMENTATION

Step 1: Pre-processing of the input image by removing the Skull part and noise

1. The image is taken as input and the area taken by each component is found out. Label 0 is ignored since this is the background.
2. Get label of largest component by area
3. Get pixels which correspond to the brain
4. In a copy of the original image, clear those pixels that don't correspond to the brain to obtain the final images.
5. Then the image is converted into grayscale and is blurred using median filter of Kernel 5 by 5 to remove noise.

Step 2: Global Threshold segmentation is applied to the Pre-processed image of step 1

1. Threshold segmentation of the image is performed using gray scale value of 160, the value is chosen as hyper parameter
2. Finally, the images of Pre-processed skull removed image and the image obtained after performing Threshold Segmentation are plotted.

Step 3: K-means clustering is applied to the Pre-processed image of step 1

1. First the image is converted into RGB color space.
2. RGB value of each pixel is vectorized to 3 columns
3. K-means clustering is performed using the criteria and k-means functions of OpenCV. K value is chosen as 3. The Centers of the Cluster is obtained.
4. Finally, the images of K-means segmented image and the resulting image with the tumor part are plotted.

Step 4: Watershed segmentation is applied to the Pre-processed image of step 1

1. Noise is removed
2. Find the sure foreground area
3. Find the unknown region
4. Add 1 to all labels so that sure background is not 0
5. The region of unknown is marked with zero
6. A new image is created to show the results. It only displays the portion of image where marker is defined.
7. Finally, the images of watershed segmented image with markers and the resulting image with the tumor part are plotted.

Step 5: Level set segmentation is applied to the Pre-processed image of step 1

1. Chan_vese method is used for detecting active contours
2. Finally, the images of Level set segmented image with final level set and the resulting image with the tumor part are plotted.

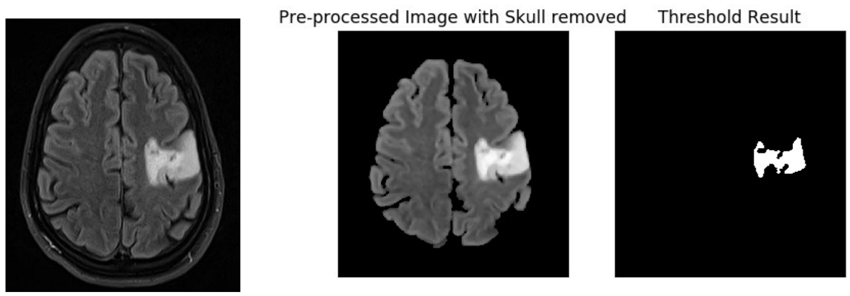
Step 6: System accuracy, sensitivity, specificity and precision are evaluated based on the following attributes.

- TP (True Positive): Existing tumor and detected correctly.
- TN (True Negative): Non-existing tumor and not detected.
- FP (False Positive): Non-existing tumor and detected.
- FN (False Negative): Existing tumor and not detected.

Step 7: Finally, the Statistical and Visual analysis such as evaluating the accuracy, sensitivity, specificity and precision of each segmentation techniques is performed to figure out the best method.

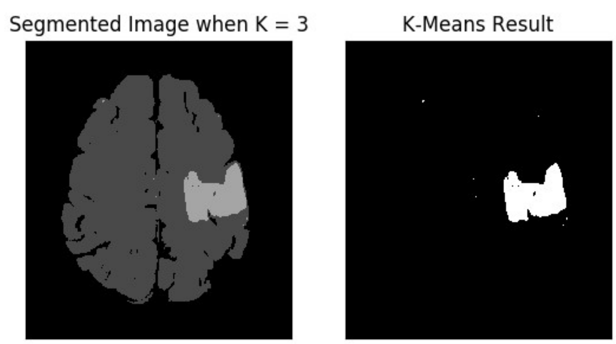
III. RESULTS AND DISCUSSIONS

A computer system with an Intel Core i5-7200U CPU @ 2.50GHz 2.71 GHz processor is used for software implementation and the performance test. All the segmentation techniques are simulated using PyCharm Community edition 2017.3.7 with Python as the programming language.



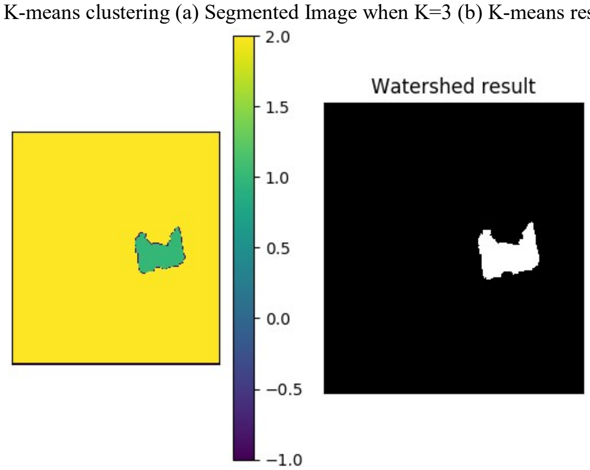
(a) (b) (c)

Fig. 1. (a) Input Brain MRI Image (b) Pre-processed Image with Skull removed (c) Threshold result obtained after performing Threshold Segmentation.



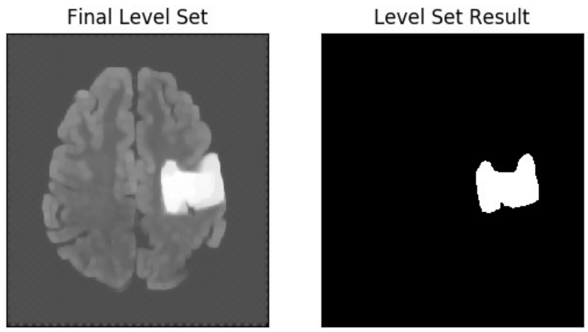
(a) (b)

Fig. 2. K-means clustering (a) Segmented Image when K=3 (b) K-means result.



(a) (b)

Fig. 3. Watershed Segmentation (a) Segmented Image using Watershed segmentation with markers (b) Watershed result.



(a) (b)

Fig. 4. Level Set Segmentation (a) Final Level Set (b) Level Set result.

Figure. 1. (a) is the Input Brain MRI Image. The dataset of MRI images of the Brain are taken from Kaggle which are available in the link https://www.kaggle.com/navoneel/brain-mri-images-for-brain-tumor-detection. Four different segmentation techniques are applied i.e threshold based, k means based, watershed based and Level set based. In this study, 80 tumor images and 20 non tumor images are considered for implementation i.e. a total of 100 images in the dataset are tested.

Performance of different segmentation techniques is compared by calculating various parameters such as TP (True Positive) i.e. Existing tumor and detected correctly, TN (True Negative) i.e. Non-existing tumor and not detected, FP (False Positive) i.e. Non-existing tumor and detected and FN (False Negative) i.e. Existing tumor and not detected. Specificity, sensitivity, precision and accuracy are calculated from the above parameters.

Sensitivity is the measure of successful determination of the person having a tumor.

$$Sensitivity = \frac{TP}{TP + FN}$$

Specificity is the measure of successful determination of the person not having a tumor.

$$Specificity = \frac{TN}{TN + FP}$$

Accuracy is the measure of successful classification.

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

Precision is the measure of how many of those which are labeled as tumor are actually tumor.

$$Precision = \frac{TP}{TP + FP}$$

TABLE-1

THE COMPARISION OF THE PROPOSED SYSTEM FOR A TOTAL OF 100 IMAGES.

	TP	TN	FP	FN	Sensitivity	Specificity	Accuracy	Precision
Threshold Segmentation	71	19	1	9	88.75%	95%	90%	98.61%
K-means clustering	65	19	1	15	81.25%	95%	84%	98.48%
Watershed Segmentation	74	19	1	6	92.5%	95%	93%	98.66%
Level Set Segmentation	70	14	6	10	87.5%	70%	84%	92.10%

Table-1 shows the comparision of the proposed system for a total of 100 images. 80 images were tumor images and 20 were non tumor images. Performance of 4 segmentation techniques such as Threshold segmentation, K-means clustering. Watershed segmentation and Level set segmentation are compared by calculating various parameters such as TP (True Positive), TN (True Negative), FP (False Positive) and FN (False Negative). Further specificity, sensitivity, precision and accuracy is calculated from the above parameters.

Some of the images are identified as without a tumor incorrectly. The reason of this mulfunctioning was due to the fact that there is no clear distinction between the tumor area and the rest of the brain in terms of intensity of the pixels.

IV. CONCLUSION

A comparison between Threshold based, K means clustering based, Watershed based and Level set-based segmentation methods are performed to detect the tumor region of the brain. Statistical and Visual analysis is performed to figure out the best method. Threshold based segmentation was one of the simplest methods to implement. However, it was not able to distinguish the tumor part properly since most of the times Threshold based segmentation is used as pre-processing step. K-means clustering was not able to detect tumors which are small and which are light in appearance. Watershed segmentation had the highest accuracy in detecting tumor part compared to all the four techniques. It was able to detect almost exact tumor shape but not better than the level set segmentation. Level set segmentation had the second highest accuracy among all and was able to detect the exact tumor shape but it took the longest time to display results (3-10 seconds of delay). The Level set also misclassified the tumor more i.e. detecting non existing tumor. Finally, based on the statistical and visual analysis, it is being concluded that Watershed segmentation technique was the best among all the segmentation techniques. This research could help clinicians in surgical planning, treatment planning and accurately segmenting the tumor part with the most accurate method.

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