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Comparative Evaluation of Thresholding and Segmentation Algorithms

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***Abstract*— Segmentation of brain tumor manually consumes more time and it is a challenging task. This paper detects the tumor inside the brain by doing segmentation and extraction of the tumor which is been detected. To prove the efficiency of the detection of brain tumor we have performed a comparative study of two segmentation algorithms namely "watershed segmentation algorithm" and "k-means clustering segmentation algorithm". After the segmentation process the various morphological operations are applied on the segmented image. The morphological operations are applied to concentrate only on the required tumor part and ignoring the remaining area in the brain. The various thresholding algorithms like "Otsu's thresholding" and "brute force thresholding" is applied to improve the efficiency of the final output image.**

Comparative study is made between the segmentation algorithms and the thresholding algorithms used. The further step of this project is to present an analytical method to detect tumors in medical images for 3D representation or visualization.

***Keywords*— MRI, Tumor, Segmentation, Thresholding, Morphological Operation, 3D Visualization.**

I. INTRODUCTION

Brain tumor occurs when there is an abnormal growth of tissues or cells in the brain. There are various stages of brain tumor according to which they are classified as benign, malignant and pre-malignant. In recent researches it has been proved that the loss of life due to brain tumor has been increasing. Magnetic Resonance Imaging is the commonly used method to detect brain tumor. Depending on the MRI scan physicians determine the existence of tumor. To make the detection of tumor more accurate an efficient, we have applied this method. We use matlab, which is a commonly used tool for image processing. Various algorithms have been used and compared for calculating the efficiency and computing the effective output.

II. METHODOLOGY

A. *RGB to Grayscale*

Grayscale digital image is an image that carries only intensity information. They are composed exclusively of shades of gray, where black has the lowest intensity and white has the highest. Grayscale images can be synthesized from a full colour image. Shown below is the conversion of RGB to grayscale.

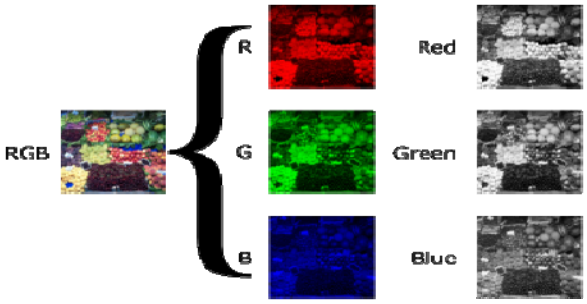

Fig. 1 RGB to Grayscale

B. *Filtering*

Filtering is a process used to suppress either the high frequency component or the low frequency component in an image. An image can be filtered either in frequency domain or spatial domain.

- High Pass Filter
  High pass filter allows to pass high frequency components beyond cut off frequency and attenuates low frequency components in the image. It is a sharpening second order derivative filter. HPF image can be obtained by subtracting low pass filter image from the original image.
- Median Filter
  Median Filter is used to remove the salt and pepper noise where salt corresponds to maximum pixel value 255 and pepper corresponds to minimum pixel value zero. It smoothen the image by selecting median of the neighbourhood pixels. That is, the output pixel value at (x, y) position is obtained by selecting the median of neighbourhood input pixel values.

C. *Segmentation*

Segmentation subdivides an image into its constituent's parts or objects. Segmentation should stop when the objects of interest in an application have been isolated.

- Watershed Segmentation
  Watershed is region based segmentation technique, in which image is partitioned into regions based on the similarity in gray levels, the watershed finds out the boundary of the region of interest and marks only that region with black pixels and ignores the rest of the region. It is faster as compared to other segmentation technique.

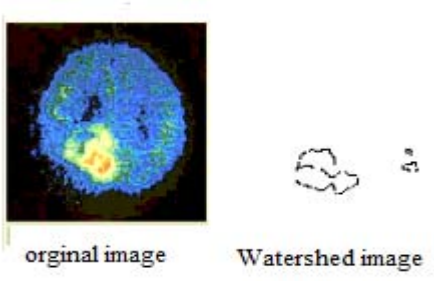

Fig. 2 Example of Watershed Segmentation

- K-means Segmentation
  K-means clustering is a segmentation technique which classify or group different objects in an image based on attributes or features into k number of groups. In this we have to define k centres for k clusters which are normally far away from each other. The choosing of k is random. The pixels in the cluster are grouped together based on minimum distance attribute. Distance can be calculated using Euclidean distance formula. After this we again have to calculate the new centre for each cluster based on the pixels of that cluster. We have to follow the same method and group the pixels based on new centre. In every step centroid changes and pixels move from one cluster to another. We have to repeat the process till no pixels is moving from one cluster to another.

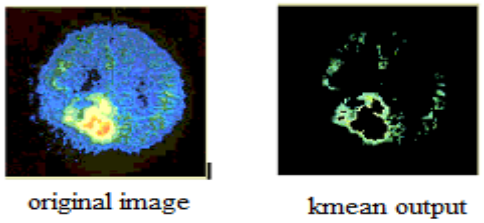

Fig. 3 Kmeans Segmentation

D. Thresholding

We have performed thresholding with two algorithms. Thresholding method is used to convert the whether grey level or binary image into black and white pixels.

- Otsu's thresholding
  Otsu's thresholding provides global thresholding. A global threshold value is computed automatically which is used to get an intensity image into a binary image with im2bw. There is no code specified for eliminating noise before thresholding the image, so it contains some amount of noise present. Accuracy is comparatively less to brute force thresholding as it contains some amount of noise. Otsu's algorithm takes 3 seconds to produce the output. The method does not work well with variable illumination. Region of interest is less. It include unnecessary details.
- Brute Force Thresholding
  It eliminates unnecessary details. Brute force thresholding provides thresholding locally. The threshold value to be considered is specified manually by the user and then converted to binary image with im2bw.The brute force thresholding eliminates the noise present in the image before converting the image into black and white pixels. Accuracy is comparatively more as it eliminates some background noise. This algorithm produces output in 2 seconds. This method works with variable illumination. Region of interest is more.

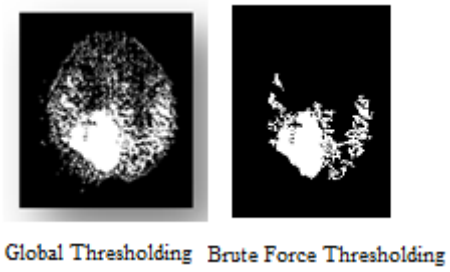

Fig. 4 Example of Global and Brute Force Thresholding

E. Morphological Operations

The main morphological operations involved are erosion and dilation. An essential element of the erosion and dilation is the structuring element. A structuring element consists of only 0's and 1's. They can have arbitrary shape and size. The dilation and erosion function accept structuring element objects called STRELs. You choose a structuring element of the same size and shapes as that of the image.

- Erosion
  To erode an image we use the imerode function. It accepts the same input as that of dilation. The erosion of an image by a structuring element produces a new binary image with all ones in a location where the structuring element hits the image. Erosion with structuring element compresses an image by taking away a layer of pixels from inner and outer boundaries of a region. The holes and gaps of different regions become bigger, and small details are removed. If we consider an image f and a structuring element s the erosion process produces a binary image g which is given by $g = f \oplus s$.Erosion or dilation individually does not provide the accurate boundary of the image. Hence we use a compound operation which combines erosion and dilation.
- Dilation
  To dilate an image we use the imdilate function. It takes two primary images. The image can be a grayscale image or packed binary image. A structured element object, is given back by the strel function, or a binary matrix gives the neighborhood image of a structured element. The dilation of an image by a structuring element produces a new binary image with all zeros in a location where the structuring element hits the image. It adds a layer of pixels to the inner and outer boundaries of the region. Dilation expands the size of objects, smoothest object boundaries, closes holes and gaps. If we consider an image f and a structuring element is the erosion process produces a binary image g which is given by: $g = f \ominus s$.

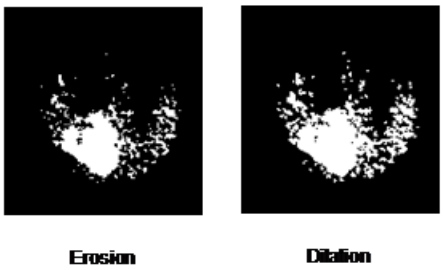

Fig. 5 Example of Erosion and dilation

F. Canny Edge Detection

The Canny edge detection method finds edges by calculating local maxima and the gradient. The gradient is calculated by computing the derivative of the Gaussian filter. In this method two threshold values are used one to detect the strong edge and the other to detect the weak edge. A high threshold value is used for low edge sensitivity and a low threshold value for high edge sensitivity. The weak edge is included in the output only if it is connected to the strong edge. This method is more efficient than other methods as it is not likely to be affected by noise and it can detect weak edges more easily.

III. 3D Representation

We extend our project to represent the detected tumor as a 3D visualization. We have made use of a software called 3D slicer which creates a 3D visualization of the detected tumor. 3D slicer is an open source software platform for medical image processing and 3D visualization of image data. Displays a rendered 3D view of the scene along with some visual references to clarify its spatial orientation (A=anterior, P=posterior, R=right, L=left, S=superior, I=inferior).Three default slice viewers are provided (with Red, Yellow and green coloured bars) in which Axial, Saggital, Coronal or Oblique 2D slices of volume images can be displayed. 3D visualization can also be provided using the MATLAB software. MATLAB of version 2011 supports creating 3D visualization. We have been working on both the methods to present a 3D model.

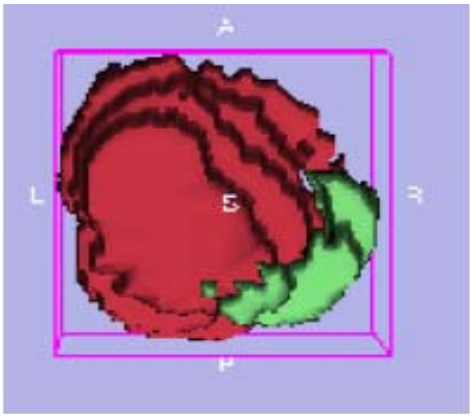

Fig. 6 Example of 3D representation

IV. Result

TABLE I
COMPARISON TABLE OF SEGMENTATION AND THRESHOLDING FOR INPUT IMAGES

TYPE	SNR	PSNR	MSE	TIME	ACCURACY
Watershed segmentation	27.544	42.128	251.351	0.019	38.68%
K- means segmentation	6.4305	27.342	127.210	0.195	52.12%
Global thresholding	6.3272	22.651	353.166	0.007	86.36%
Brute force thresholding	6.3182	22.665	352.081	0.020	88.45%

V. Conclusion

In this we made comparison between two segmentation algorithm which is watershed and kmeans. In watershed segmentation, the resulting boundaries form closed and connected regions. The boundaries of the resulting regions always correspond to contours of objects. The union of all the regions forms the entire image region. Watershed leads to over segmentation, thus we have considered kmeans clustering algorithm. Though we have to consider the number of cluster manually for accurate results, K-means clustering is considered to be quite fast segmentation method when compared to watershed. We have also made a comparison between the thresholding algorithms which are Otsu's and brute force. Otsu's thresholding automatically calculates the threshold point and converts the image into black and white pixels based on that point. To improve efficiency we have considered brute force wherein the threshold point is specified manually. As a result the region of interest considered is more effective.

VI. Future Work

The proposed application can be further extended to find the different types of tumor using neural networks in image processing. The type of tumor can be identified by calculating the volume and intensity of the identified tumor. A modified Probabilistic Neural Network (PNN) model with image analysis and manipulation techniques is proposed to carry out brain tumor classification automatically using MRI-scans.

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