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Watershed Segmentation Brain Tumor Detection

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***Abstract*—Detection of brain tumor is one of the emerging topics of research in biomedical image processing. Accurate detection is critical, especially when the tumor morphological changes remain subtle, irregular and difficult to assess by clinical examination. This paper illustrates the ability of watershed segmentation to separate the abnormal tissue from the normal surrounding tissue to get a real identification of involved and noninvolved area that help the surgeon to distinguish the involved area precisely. At the end of the process tumor is extracted from the MR image and its exact position and shape are determined and various parameters like perimeter, eccentricity, entropy and centroid have been calculated.**

Keywords:Brain Tumor; Connected Component labeling (CCL).Magnetic Resonance Imaging (MRI); Watershed Segmentation.

I. INTRODUCTION

Brain tumor is an abnormal growth of cells within the brain or inside the skull. Brain tumor classification is based on the type of tissue involved, the location of the tumor, benign or malignant, and other considerations. Primary brain tumors originate in the brain and are named for the cell types from which they originate. They can be benign (non cancerous), meaning that they do not spread elsewhere or invade surrounding tissues. Secondary brain tumors are always malignant [1].

In last two decades, several techniques have been developed by researchers to identify and locate anatomical structure from different modalities such as X-Ray, CT scan and Magnetic Resonance Imaging (MRI). The MRI scan is more comfortable than CT scan and X-Ray for diagnosis. As there is no radiation, it does not affect the human body. MR imaging uses a powerful magnetic field, radio frequency pulses and a computer to produce detailed picture of organs, soft tissues.

Nowadays there are several methodologies for classifying MR images. Amongst all medical image process techniques, image segmentation is performed initial. Manual segmentation is an alternate method for segmenting an image to extract important information [2]. This method is not only tedious and time consuming but also produces inaccurate results. This paper presents work on watershed algorithm with Connected Component Labeling (CCL) for brain tumor segmentation. The behavior of the algorithm depends on multiparameter calculation. The platform used for tumor detection is Matlab.

II. LITERATURE REVIEW

A large variety of different segmentation approaches for images have been developed and published which have its own assumptions, advantages, and limitations. Different tumor segmentation methods are shown in Fig.1.

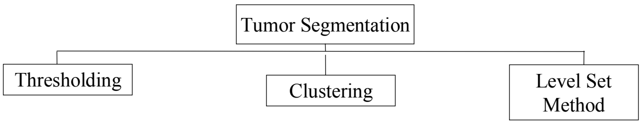

Fig.1. Different Tumor Segmentation Methods

A. *Thresholding*

Thresholding based segmentation discriminates pixels according to their gray level value. The key parameter in the thresholding process is the choice of threshold value. This procedure determines an intensity value, called threshold, which separates the desired values. Failing to find such a threshold may lead to poor segmentation[3].

B. *Clustering*

Clustering is dividing of data into groups of similar objects. Each group consists of objects that are similar between themselves and dissimilar to objects of other groups. But, its major disadvantage is that it does not produce same result with each run, because the resulting clusters depend on initial random assignments and some images may not have appropriate keywords to describe them and therefore the image search becomes different[4].

C. *Level Set Method*

This technique represents the evolving contour using a signed function, where its zero level corresponds to the actual contour. The limitation of level set method are that the 3D level sets are relatively slow to compute and their formulation usually entails several free parameters, which can be very difficult to correctly tune for specific applications. Thus level set segmentation is not sufficient for the segmentation of the complex medical images and they must be combined with powerful initialization techniques to produce successful segmentation [5].

Keeping in mind the limitation of existing brain tumor segmentation methods, this paper presents CCL based

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watershed algorithm to identify and segment the brain tumor in patients efficiently which requires quick processing time and minimize the over segmentation problem to a large extent. Watershed segmentation uses intensity as a parameter to segment the whole image data set [6].This segmentation is reliable approach to achieve a proper estimation of tumor area. In all possible methods for this purpose, watershed can be used as a powerful tool which implicitly extracts the tumor surface.

III. PROPOSED METHOD

The proposed system has four modules namely preprocessing, segmentation, CCL and multi parameter calculation. Preprocessing includes filtering of image. Segmentation is carried out by watershed algorithm. Using CCL location is found out and area is calculated of tumor in MR image.

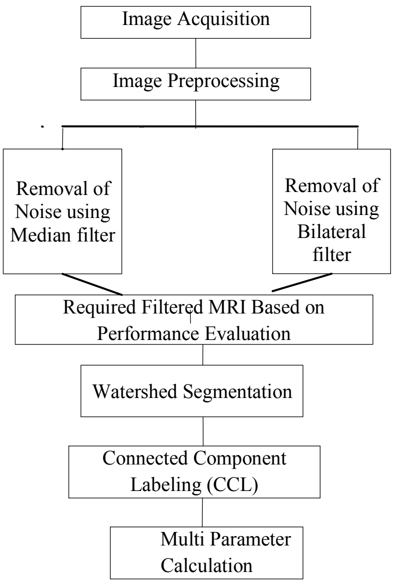
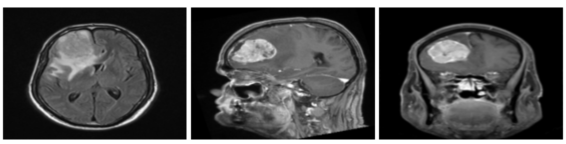


Fig.2Block Structure of Proposed Method

*(i)*Image Acquisition

Images of patient obtained by MRI Scan are of three types: axial images, saggital images, coronal image is shown in Fig.3.The numbers of images depend on the resolution of the movement of the MRI magnets.



Axial slices Saggital slices Coronal slices

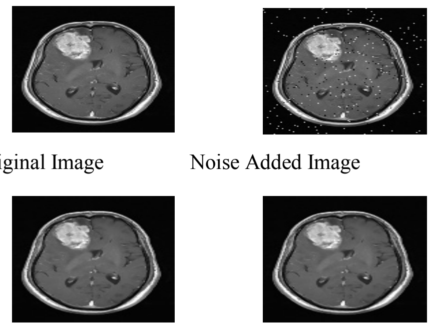
Fig.3 MRI Image For Brain Tumor.

MRI scan images of patient are displayed as an array of pixels (a two dimensional unit based on the matrix size and the field of view) and stored in Malab. Grayscale or intensity images are displayed of default size 256 x 256. All the MRI examinations were performed on a 0.35T magneto vision scanner (Siemens-syngo-fast view).

(ii) Image Preprocessing

It performs image filtering and sharpens the edges in the image. RGB to gray conversion and reshaping also takes place. For removal of noise median filter and bilateral filter have been used.

Median filter technique calculates the median of surrounding pixels to determine the new value of pixel by sorting all pixel values by their size, then selecting the median value as the new value for the pixel. The intensity value of the center pixel is replaced with median value. For better understanding the function of median filter, we add the salt and pepper noise artificially and removing it using median filter [7][8]. Bilateral filter is a non-linear technique that can blur an image while respecting strong edges. Its ability to decompose an image into different scales without causing haloes after modification has made it. Bilateral filtering is a technique to smooth images while preserving edges[9] [10].



Original Image Noise Added Image

Median Filter Image Bilateral Filter Image

Fig.4Denoising Using Median Filter & Bilateral Filter

(iii) Performance Evaluation

In order to compare different segmentation algorithms, it is better to design some methods for the evaluation. Median filter and bilateral filter are used for performance evaluation, out of which Median filter proved to be best.

(a) *Mean Square Error (MSE)*

It is defined for two m x n monochrome images *I* and *K* where one of the image is considered as noisy approximation and other is defined as

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{i=0}^{n-1}[I - K(i,j)]^2 \quad (1)$$

(b) *Peak Signal to Noise Ratio (PSNR)*

It is measure of quality of reconstruction in image compression and it is calculated as below :

$$PSNR = 10\log(Max_i^2|MSE) \\ = 20log_{10}\left(Max_i\left|\sqrt{MSE}\right.\right) \quad (2)$$

(c) *Correlation (CORR)*

The correlation coefficient $\rho_{x,y}$ between two random variables *X* and *Y* with expected values μ_x and μ_y standard deviation and is defined as

$$\rho_{x,y} = \frac{Cov(X,Y)}{\sigma_x\sigma_y} = \frac{E(X-\mu_x)(X-\mu_y)}{\sigma_x\sigma_y} \quad (3)$$

Where *E* is the expected value operator and *Cov*means covariance. Since

$$U_x = E(x) \\ \sigma_x^2 = E(x)^2 - E^2(x) \quad (4)$$

The correlation is defined only if both of the standard deviations are finite and both of them are nonzero.

(d)*Contrast parameter (H)*

An intensity image is a data matrix MATLAB stores intensity image as a single matrix, with each element of the matrix corresponding to one image pixel. MATLAB handles intensity images as indexed images. Contrast (H) is often used to characterize the extent of variation in pixel intensity.Object in an image is I(x, y).Where min H and max H represent the minimum and maximum intensity values of the neighborhood pixel $Cg(I_H)$,as shown in below equation(6). H_d is obtained by totaling the contrast of a supervised block as shown in below equation. Contrast is calculated as below:

$$I_H(x,y) = \left(\frac{I(x,y) - minH}{maxH - minH}\right) X\ maxH/H \in C_g(I_H)(5)$$

$$H_{d(r,c)} = \sum_{(x,y)\in B} I_H\ (x,y) \quad (6)$$

The following TABLE I shows the MSE, PSNR, Contrast, Correlation, values of the above filters.

TABLE I. Performance Analysis of Filter

Sr. No	Parameter	Median Filter	Bilateral Filter
1	MSE	2.9886	4.0503
2	PSNR	43.3761	42.0559
3	Contrast	0.10274	0.0099105
4	Correlation	0.99954	0.99937

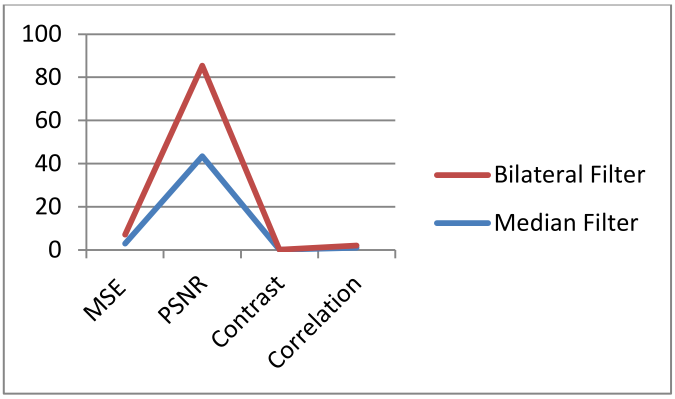


Fig. 5 Plot of MSE, PSNR, Contrast, Correlation values of Median Filter and Bilateral Filter

*(iv)*Watershed Segmentation

Watershed segmentation is a well known edge based segmentation algorithm [11].Watershed means area of land where all the water drains off it and goes into the same place. In geography, watershed line is defined as the line separating two catchment basins, as shown in Fig.6. The rains that fall on either side of the watershed line will flow into the same lake. This idea is used in image processing as a method of solving problems. Watershed segmentation into two dimension is shown in Fig.6.The principle of watershed in image processing is shown in Fig.6. Suppose the lower point in image are $B_1, B_2, B_3, ...B_z$ are coordinates of these points for the image. I(i,j)and CB_m refers to the points of catchment basins associated with the minimum region $B_z(x,y)$ represented by *X[n]* accordingly $I(x,y)<n$.

$$X[n]=\{(x,y)/I(x,y) < n\} \quad (7)$$

X[n] is the coordinate of points in *I(i,j)* geometrically lying under the plain *I(i,j)=n*. Topographically the image filled with the water in integer filling increments begin from $n=t_{max-1}$ *to n=* $n=t_{min+1}$..

The number of points under the fluid is necessary, due to that marker will used in black color for the coordinates in *X[n]* which are below the level *I(i,j)=n* and the other point in white color.

$$C_nB_m = CB_m \cap X[n] \quad (8)$$

Where C_nB_m represents the coordinates in catchment basins related to B_m, which are fluid filling at the level n.Then let *C[n]* refer to union of the filling fluid of the points of catchment basins of level *n:*

$$C[n] = \cup_{m=1}^{z} C_nB_m (9)$$

Finally C_{tmax+1} refer to all catchment basins union.

$$C_{tmax+1} = \cup_{m=1}^{z} CB_m (10)$$

From equation (8) and (9),*C[n]* is a subgroup of *X[n]* accordingly then watershed lines is prepared when

$C[t_{max}+1]=X[t_{min}-1]$.Then the procedure follows to reconstruct $C[n-1]$ at level n. $C[n]$ can be obtained from $C[n-1]$ by assuming S as the set of the connected component in $X[n]$,at $s \varepsilon S[n]$ there are three assumption.

a) $s \cap C[n-1]$ is empty and the assumption is verify at a new minimum is encountered, in this case s is incorporated into $C[n-1]$ to produce $C[n]$.

b) $s \cap C[n-1]$,contains more than one connected component of $C[n-1]$ and this lead to $s$is incorporated in to $C[n-1]$ to produce $C[n]$.

c) In last case $s \cap C[n-1]$ contains more than one connected component of $C[n-1]$ and this verify at all or part of rim separating two or more catchment basins in encumbered. Additional water is filled lead to merge the water at these catchment basins. According to that one or more than one dam must reconstruct to pervert overflow between catchment basins within s.

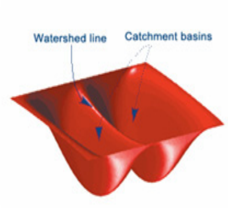


Fig.6Watershed Segmentation of Simplified To Two Dimension.

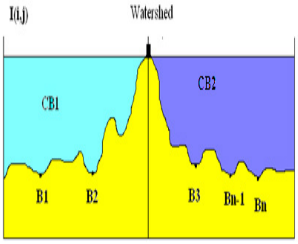


Fig.7Watershed Principle Method

(v) Connected Component Labeling (CCL)

CCL is an image and groups its *pixels* into components based on pixel connectivity .i.e. all pixels in connected component share similar pixel intensity values and are in some way connected with each other. Once all groups have been determined, each pixel is labeled with a gray level or a color (color labeling) according to the component it was assigned to.CCL works by scanning an image, pixel-by-pixel (from top to bottom and left to right) in order to identify connected pixel regions, *i.e.* regions of adjacent pixels which share the same set of intensity values V(For a binary image $V=\{1\}$;however, in a gray level image V will take on a range of values, for example: $V=\{51,52,53,...78,79,80\}$).

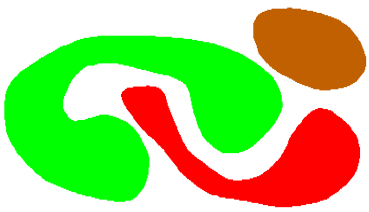


Fig.8Connected Component Labeling.

It works on *binary* or *gray level images* and different measures of *connectivity* are possible. For the following we assume binary input images and 8-*connectivity*.The connected components labeling operator scans the image by moving along a row until it comes to a point p(where p denotes the pixel to be labeled at any stage in the scanning process) for which $V=\{1\}$.when this is true, it examines the our neighbors of p which have already been encountered in the scan (*i.e.* the neighbors (i) to the left of p,(ii) above it,(iii and iv) the two upper diagonal terms).Based on this information, the labeling of p occurs as follows :

a) If all four neighbors are 0, assign a new label to p, else
b) If only one neighbor has $V=\{1\}$, assign to its label p, else
c) If more than one of the neighbors have $V=\{1\}$, assign one of the labels to p and make a note of the equivalences.

After completing the scan, the equivalent label pairs are sorted into equivalence classes and a unique label is assigned to each class. As a final step, a second scan is made through the image, during which each label is replaced by the label assigned to its equivalence classes. For display, the labels might be different gray levels or colors.

IV. RESULT AND DISCUSSIONS

In this section, the experimental results of proposed model watershed segmentation technique are presented. Input image shown in Fig.9.The input image Fig. 9(a) was processed. It is denoise MRI image using median filter, resulting image is obtained shown in Fig.9 (c). Original MR image having binary, distance transform, watershed superimposed image shown in Fig.9 (d), Fig.9(e) and Fig.9.(f) respectively. Compute CCL to dilated image whose object area is less than 500, resulting image shown in Fig.9 (g). Assign the RGB label for connected components shown in Fig.9(h).Final detected tumor from MRI image is shown in Fig.9(i). The superiority of this work is expressed in terms of area, perimeter, eccentricity, entropy, and centroid shown in TABLE II. According to this result, Watershed algorithm proves to be a more promising technique for the segmentation of tumor.

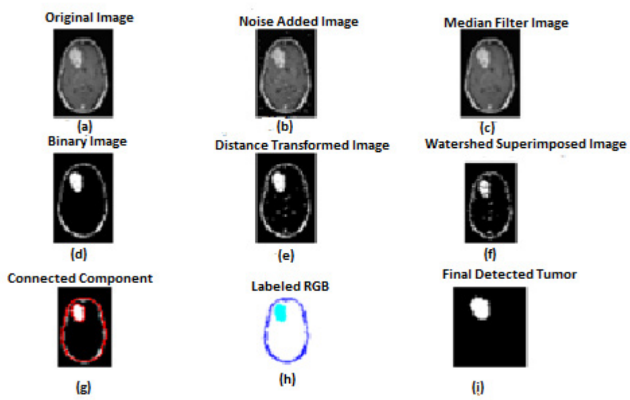


Fig.9 Tumor Detection Using Watershed Segmentation.

TABLE II. Multiparameter calculation for Watershed

Sr. No	Parameter	Watershed Segmentation
1	Area(mm^2)	3983.35
2	Perimeter(mm)	238
3	Eccentricity	0.62735
4	Entropy	0.33625
5	Centroid	X=113 Y=76

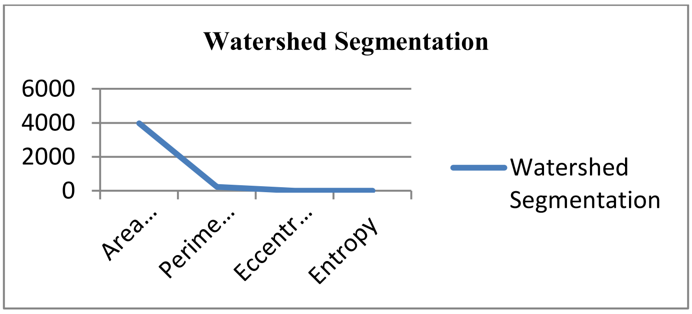


Fig.10 Plot of Parameter values derived from Watershed Segmentation

V. ADVANTAGE AND APPLICATION

The advantage of this method is its simplicity and efficiency. It can remove salt and pepper noise, high frequency component from MRI without disturbing edges. It can more accurately localize activated brain adjacent to regions of abnormal tissue such as tumors. No automatic approach yet exists for automatically and accurately computing the area. Its application to several datasets with different tumors sizes intensities and locations show that it can automatically detect and segment very different types of brain tumors with a good quality. All parameters which are extracted using developed algorithm specify the size and other dimensions of the tumor. Quantifying the area of the tumor is key indicator of tumor progression. An accurate area measurement can be used to analyze the effectiveness of new treatments

VI. CONCLUSIONS

Preprocessing can effectively detect and remove a considerable amount of the noise and artifacts with the help of median filter. Developed technique is introduced to solve the problem for tumor case of clinical MRI analysis. The proposed technique is based on Watershed segmentation and it has been successfully tested on MRI image data. Developed algorithm is used to know about the location and size of the tumor. Hence watershed segmentation with connected component labeling algorithm provides better segmentation results with area, perimeter, eccentricity, entropy with value(3983.35,238,0.62735,0.33625). All parameters which are extracted using developed algorithm specify the size and other dimensions of the tumor.

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