PES UNIVERSITY
(Established under Karnataka Act No. 16 of 2013)
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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

Course Title: Image Processing and Data Visualization Using MATLAB		
Course code: -UE19CS257B		
Semester: 4th Sem	Branch: CSE	Team Id: 9
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PROJECT REPORT

Problem Statement: To detect and segment Brain Tumours from Magnetic Resonance Images

Objective:

- To determine which segmentation method available is most appropriate to detect tumours
- To determine the correlation between background and foreground with respect to this case study

Pre-requisite Toolboxes:

- Image Processing
- Computer Vision
- Signal Processing

Description:

Treatment of Brain Tumours is challenging due to unpredictable structure, shape and texture of the tumour. This project is our attempt to make this process easier by using MATLAB's Image Processing versatility. It involves various methodologies like noise removal, filtering, segmentation and morphological operations to arrive at the right conclusion. Each MRI image goes through a series of steps where it is pre-processed (noise

removal and contrast enhancement) before it undergoes various segmentation techniques.
The 4 different segmentations performed are:

- Otsu’s Segmentation
- Watershed Segmentation
- Local Thresholding
- K-means Clustering

For each segmentation technique, normalised cross correlation value is computed to determine the accuracy and best method to segment the image.
Apart from this, we have enabled a method to compute cross-correlation between target variable and tumour region. The tumour (foreground) and skull (background) regions are taken to compute this value in the texture image. This estimates how closely the pixels of the tumour region are related to one another. 0 represents the skull region and 1 the tumour region.
Thus, this project helps increases the efficiency and precision of tumour detection in medical fields.
Step by Step Description of the project:

1) Pre-processing and Noise Removal:
   Though MRI Images look as if they are composed f only black and white colours to the human eye, this is not the case. The image consists of Red, Green and Blue tinted pixels which need to be converted to grayscale before use for better results. Noise Removal is performed using median filter. It’s a non-linear filtering technique often used to reduce “salt and pepper” noise.
2) OTSU’s Thresholding:
   Morphological transformation of the top hat is performed on the image. The top hat transformation opens an image, subtracts the open image rom the original image. This enhances the contrast in a grayscale image with non-uniform lighting which is the case with most MRI images. The structuring element used is a disk which defines the neighbourhood matrix for any pixel. Erosion is performed to remove islands and small objects so that only substantive objects remain.
3) Local Thresholding:
   It is the simplest segmentation technique which converts a grayscale image to a binary image. This is done based on a value called

threshold value. The threshold value selected is (t0 + (maximum pixel value in the image) + (minimum pixel value in the image))/2. Here, we have set the value of t0 to 50. It can be altered. Pixel values are set to 1 or 0 based on whether its value is greater than or lesser than the threshold value. Threshold value when selected appropriately can yield efficient results.

4) K-Means Clustering:
It is an unsupervised segmentation technique where the initial set of clusters(k) along with their cluster centres need to be initialised before segmenting. Segmenting the tumour is entirely dependant on the value of k. In this case, we have chosen the value k=4. We segment our image into 4 different regions each represented by a different colour. The image is converted into linear space using the reshape command. This image is then passed as input to k-means. The image after segmentation is converted back to spatial domain.

5) Watershed Segmentation:
This segmentation technique is useful to segment objects which are in close contact with each other because this algorithm helps in finding the catchment basins and ridge lines. Watershed() function returns a labelled matrix which consists of positive integer values for different regions and 0 for ridge lines. Since the images have reasonable contrast, catchment basins can be extracted efficiently using this method.

6) Normalised Cross Correlation:
After extracting the tumour from the image by performing appropriate segmentation techniques and morphological operations, correlation is performed to determine the if the tumour extracted can be accurately determined as a tumour. For this normalized cross correlation has been performed using the function normxcor2(). In this process, we compare the tumour extracted with the MRI image. If it results in a high positive value (that is value close to 1), we can say that the given tumour is highly correlated with the image. That is tumour is extracted efficiently with less noise. Otherwise, the tumour extracted has some noise in that image due to which correlation value reduces. This normalized cross-correlation technique has been applied on every segmentation technique.

7) Cross Correlation:
Image is converted to double and appropriate texture filter method is applied to determine the texture features of the image using the

rangefilt() function. Smoothing filter uses the filter matrix provided by the programmer to smoothen the image. The foreground (tumour) regions and background (skull) regions are extracted using the ginput() command. Cross correlation is applied to compute the correlation between target variable and tumour region in order to determine the degree to which the pixels of the tumour region are closely correlated with each other. xcorr2() command is used to compute the cross correlation.

New Concept Learnt (Explanation):
The project introduces many concepts involved in the domain of Image Processing. We explored various segmentation techniques apart from the ones mentioned like MSER Segmentation, Graph Cut, Active Contour, etc to gauge which technique suits our dataset the best. Morphological operations are another new concept we picked up. To compare the various techniques explored, we learnt to evaluate the performance of each using Normalised Cross Correlation. Cross Correlation was also used to evaluate how closely the pixels are related.

Learning Outcome:
Upon completion of this project, one will gain insights on how to extract any desired portion from an image. It will also enable one to understand which techniques can be used to evaluate on an image based on how the image was take, the lighting conditions, the portion to be extracted.

Code:

```
function braintumour()
%read image
img=imread("C:\Users\Anusha
V\Documents\MATLAB\BrainTumour\dataset\IM_00014q.TIF");
figure,imshow(img);
title('Original image');
pause(3);
imagesc(img);
colormap(gray);
title('ColorMap of Array Values');
pause(3);
%displays the size of image
disp('Size of image:');
disp(size(img));

%Check if the image is an RGB image
if(size(img,3) > 2)
img=rgb2gray(img);
imagesc(img);
colormap(gray);
pause(3);
```

```
end

%Converting image to double
im_dbl=im2double(img);
%removes noise by applying median filter
im_median=medfilt2(img);
imshow(im_dbl);
title('Image in double precision');
imshow(im_median);
title('After Applying Median Filter to remove noise');


%OTSU'S THRESHOLDING
%performs the morphological filtering of the top hat in the grayscale or binary
image,
%returning the filtered image. Top hat filtering calculates the morphological
aperture of the
%image (using structuring element), and then subtracts the result from the
original image.
%strel -> structuring element used in the top hat filtering
im_thresh=imtophat(im_median,strel('disk',40));
imshow(im_thresh);
title('Image after top hat filtering');
pause(3);
%improves the contrast of the image
im_adjust=imadjust(im_thresh);
imshow(im_adjust);
title('Improved contrast');
pause(3);
%determines the threshold value to perform segmentation
threshold_level=graythresh(im_adjust);
%segments the image into two classes: 0 if less than threshold_level and 1 if
greater
%or equal to threshold_level
BW=imbinarize(im_adjust,threshold_level);
imshow(BW);
title('Binarized image');
%creating structural element
strel_erode=strel('disk',3);
%Performing morphological erosion
im_erode=imerode(BW,strel_erode);
imshow(im_erode);
title("Otsu's thresholding");
pause(5);

%performs normalized cross correlation
norm_corr=normxcorr2(im_erode,img);
disp('Normalised Cross Correlation Value for Otsu Thresholding');
disp(max(norm_corr(:)));
pause(5);


%LOCAL THRESHOLDING

%setting lower threshold value
t0=50;
%upper threshold
th= t0+((max(im_median(:))+min(im_median(:)))./2);
seg_img=zeros(size(im_median,1),size(im_median,2));
%setting values to zero or one based on the threshold value obtained
for i= 1:1:size(im_median,1)
    for j=1:1:size(im_median,2)
        if im_median (i,j)>th
            %sets to 1 if greater than threshold
```

```
            seg_img(i,j)=1;
        else
            %sets to 0 if lesser than threshold
            seg_img(i,j)=0;
        end
    end
end


figure,imshow(seg_img);
title('Image after setting values to 0 and 1 after thresholding')
pause(3);

%Creating a structuring element
strel_erode=strel('disk',3);
%performs morphological erosion
im_erode=imerode(seg_img,strel_erode);
imshow(im_erode);
title('After first morphological erosion');
pause(3);

%performing morphological dilation with disk as the structuring element
strel_dilate=strel('disk',3);
im_dilate=imdilate(im_erode,strel_dilate);
imshow(im_dilate);
title('After morphological dilation');
pause(3);

%performs morphological erosion with disk as the structuring element
im_erode1=imerode(im_dilate,strel_erode);
imshow(im_erode1);
title('Local Thresholding');
pause(5);


%performs normalized cross correlation
norm_corr=normxcorr2(im_erode1,img);
disp('Normalised Cross Correlation Value for Local Thresholding')
disp(max(norm_corr(:)));
pause(5);


%WATERSHED SEGMENTATION

%morphological operation
im_thresh=imtophat(im_median,strel('disk',40));
figure,imshow(im_thresh);
title('Top-hat filter with disk-40 structuring element')
pause(3);
%improves the contrast of the image
im_adjust=imadjust(im_thresh);
imshow(im_adjust);
title('Improving contrast')
pause(3);
%determines the threshold value
threshold_level=graythresh(im_adjust);
%segments the image using Otsu's threshold
BW=imbinarize(im_adjust,threshold_level);
imshow(BW);
title('Binarized image');
pause(3);
%performs morphological erosion with disk as a structuring element
strel_erode=strel('disk',3);
%performs erosion with a structuring element of shape disk
```

```
im_erode=imerode(BW,strel_erode);
imshow(im_erode);
title('Eroded image')
pause(3);
%take the compliment of the result
comp=~im_erode;
imshow(comp);
title('Compliment of eroded image');
pause(3);
%compute distance between every pixel to every non-zero pixel
dist=-bwdist(comp);
dist(comp)=-Inf;
%apply watershed segmentation to get the labelled image
label=watershed(dist);
%convert the image to rgb
img_final=label2rgb(label,'gray','w');
imshow(img_final);
title('Watershed segmentation');
pause(5);

%performs normalized cross correlation
norm_corr=normxcorr2(rgb2gray(img_final),img);
disp('Normalised Cross Correlation Value for Watershed Segmentation')
disp(max(norm_corr(:)));
pause(3);


%K-MEANS CLUSTERING

%converts image to linear shape
img_reshape=reshape(im_median,[],1);
%apply k-means with k value as 4
[imgVecQ,~]=kmeans(double(img_reshape),4);
%arranging back into image
img_res=reshape(imgVecQ,size(im_median));
figure,imagesc(img_res);
pause(3);
subplot(3,2,1),imshow(img_res==1,[]);
title('First Subplot');
subplot(3,2,2),imshow(img_res==2,[]);
title('Second Subplot');
subplot(3,2,3),imshow(img_res==3,[]);
title('Third Subplot');
subplot(3,2,4),imshow(img_res==4,[]);
title('Fourth Subplot');
pause(3);

%perform normalized cross-correlation for each cluster
norm_corr=normxcorr2(img_res==1,img);
disp('K-means cluster 1 Nomarlized Cross COrrelation')
disp(max(norm_corr(:)));
pause(3);

norm_corr=normxcorr2(img_res==2,img);
disp('K-means cluster 2 Nomarlized Cross COrrelation')
disp(max(norm_corr(:)));
pause(3);

norm_corr=normxcorr2(img_res==3,img);
disp('K-means cluster 3 Nomarlized Cross Correlation')
disp(max(norm_corr(:)));
pause(3);

norm_corr=normxcorr2(img_res==4,img);
```

```
disp('K-means cluster 4 Nomarlized Cross Correlation')
disp(max(norm_corr(:)));
pause(3);

% smoothing filter matrix
filter_matrix=[1 1 1 1 1 1 1 ;
                  0 0 0 0 0 0 0];

%texture filter is applied to determine the texture image
img_texture=rangefilt(im_dbl);
%applying smoothing filter on the texture image
img_texture=imfilter(img_texture,filter_matrix);
figure,imshow(img_texture);

%takes coordinates of tumour region
[row,col]=ginput();
tumour_region=[row,col];
%determine the texture values of the tumour region
val_tumour=impixel(img_texture,tumour_region(:,1),tumour_region(:,2));

figure,imshow(img_texture);
%take coordinates of the skull region
[rols,cols]=ginput();
skull_region=[rols,cols];

%determine the texture values of the skull region
val_skull=impixel(im_dbl,skull_region(:,1),skull_region(:,2));
disp(val_skull(:,1));

%target variable is a vector which divides into two classes :0 represents
%skull region and 1 represents tumour region
target_variable=[zeros(numel(val_skull(:,1)),1);
ones(numel(val_tumour(:,1)),1)];

%making the dimensions of the target variable and tumour region same
val_tumour=[val_tumour(:,1);zeros(length(target_variable) -
length(val_tumour),1)];

%compute cross correlation
correlation=xcorr2(target_variable,val_tumour);
disp(max(correlation(:)));

end
```

Output Screenshots

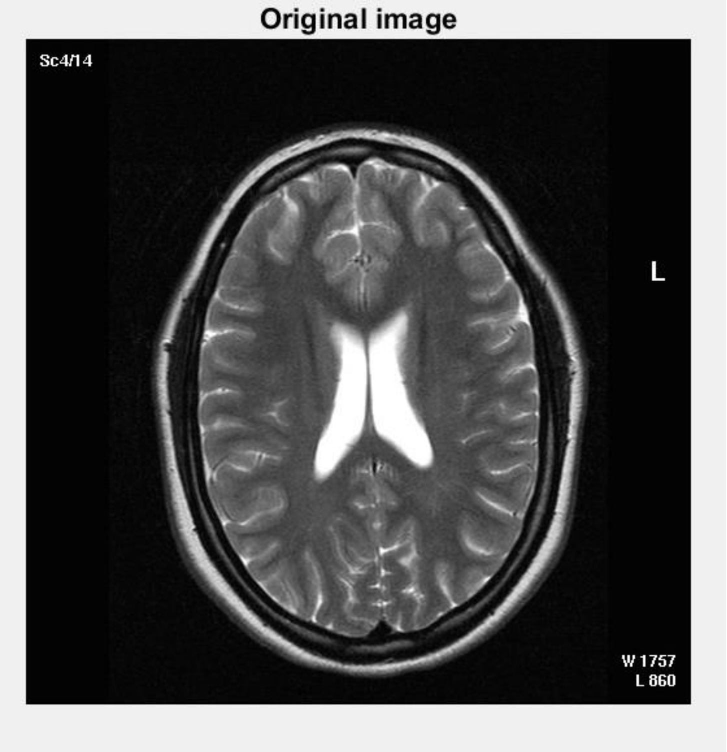

Fig1. Input Image

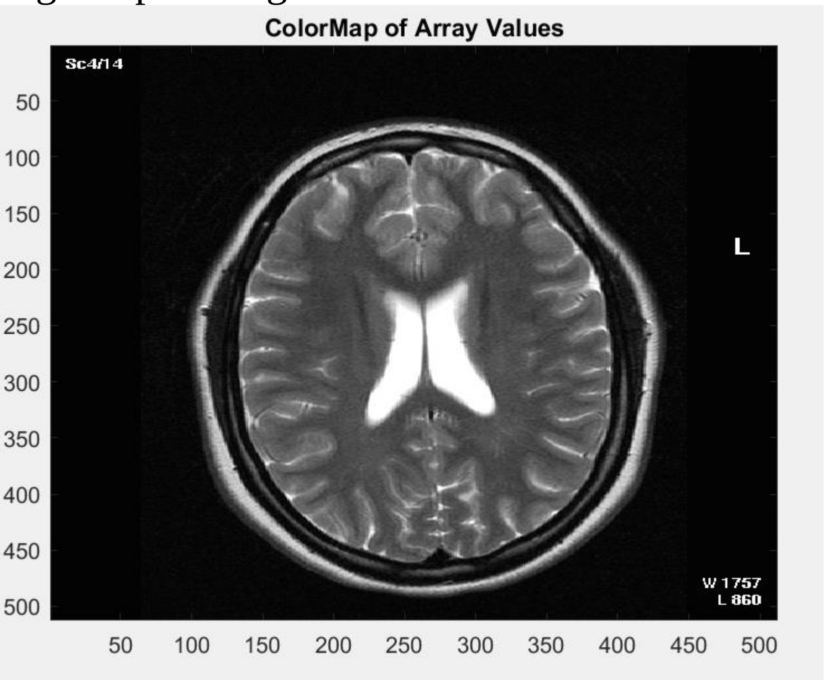

Fig2.ColorMap of Array Values

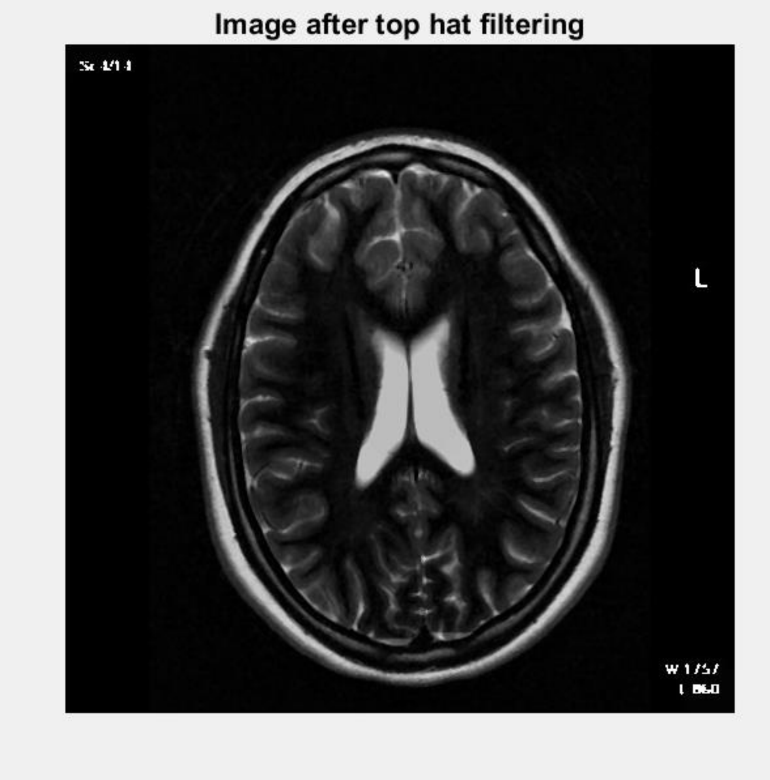

Fig3. Image after top hat filtering

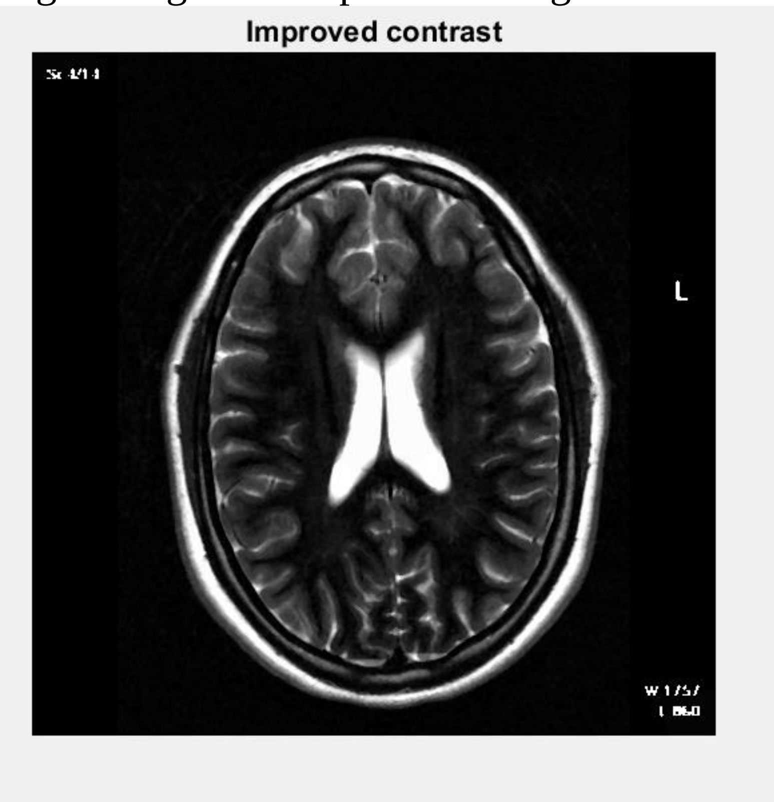

Fig4.After adjusting the contrast

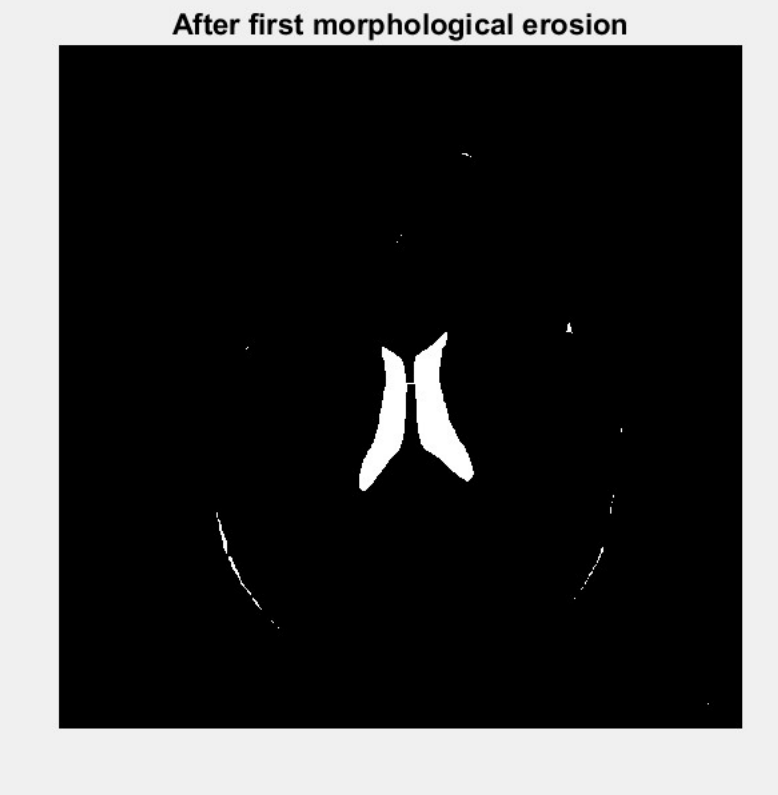

Fig5.Performing Morphological erosion using structural element

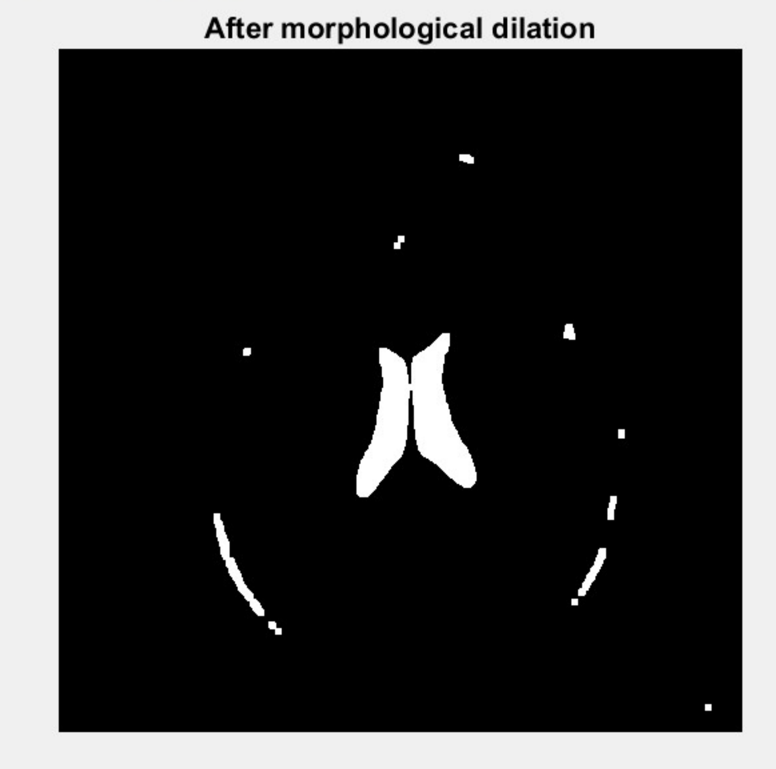

Fig6. Performing Morphological dilation

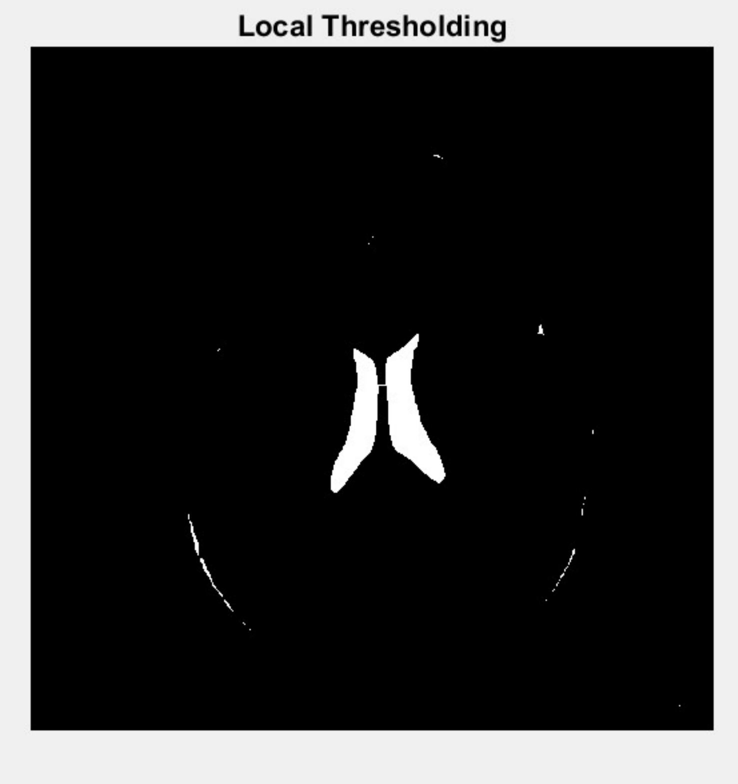

Fig7.Local Thresholding Segmentation

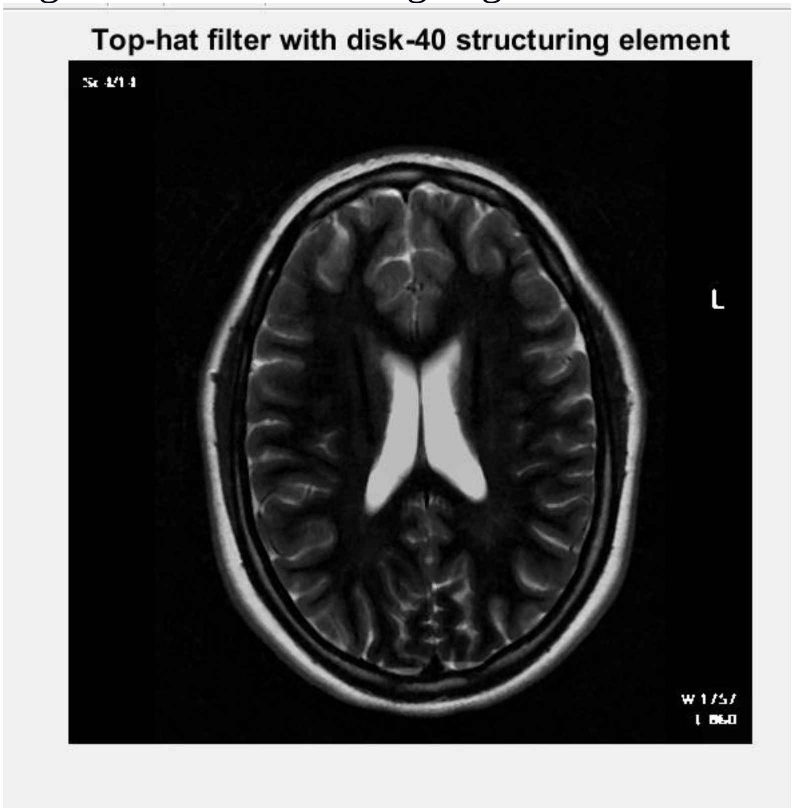

Fig8.Top-hat filtering with disk 40 structuring elements

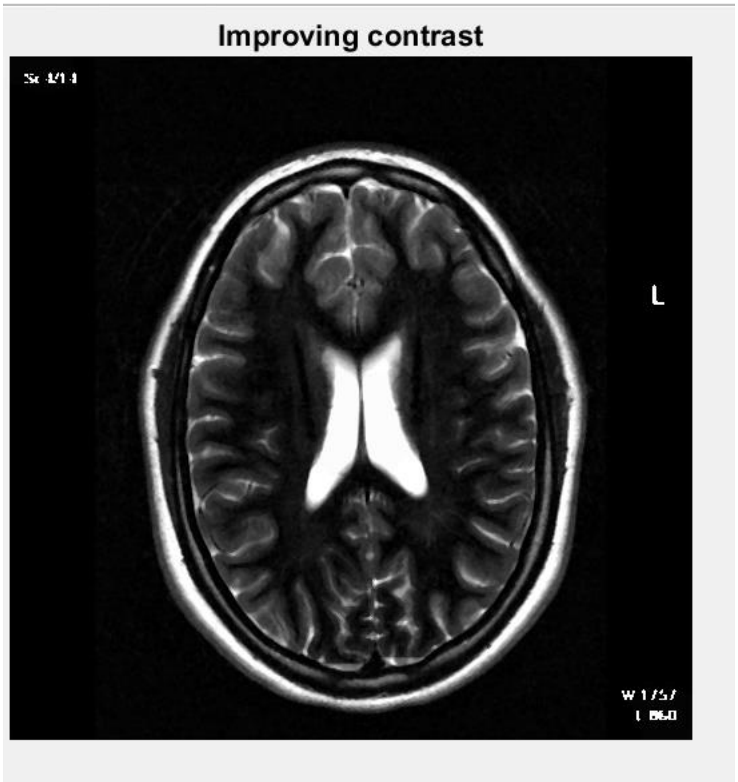

Fig9.Improving contrast

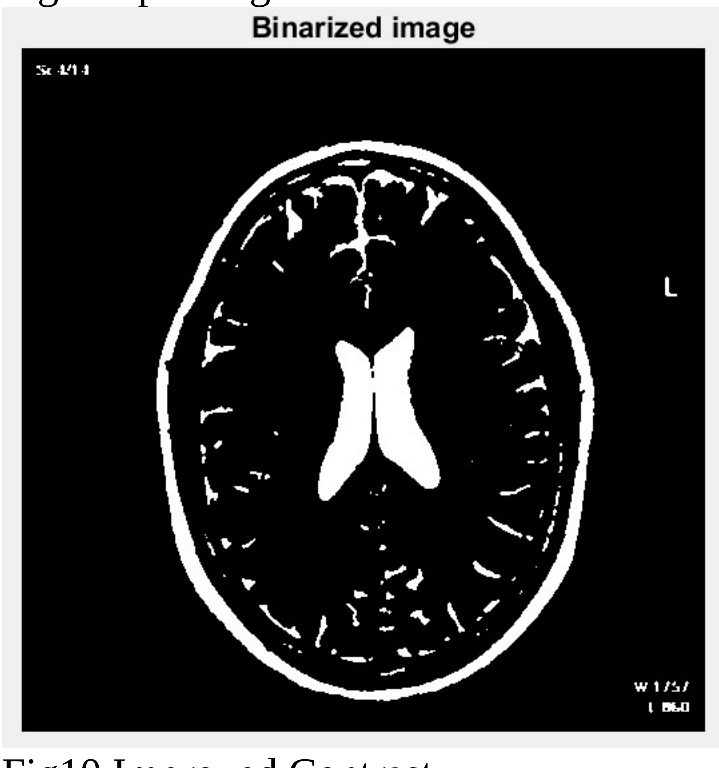

Fig10.Improved Contrast

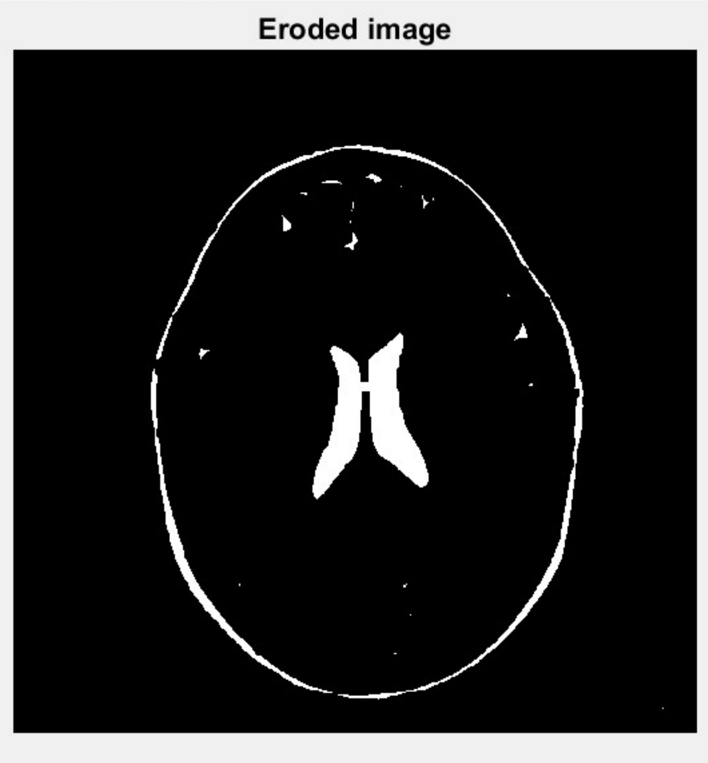

Fig11.Eroded Image

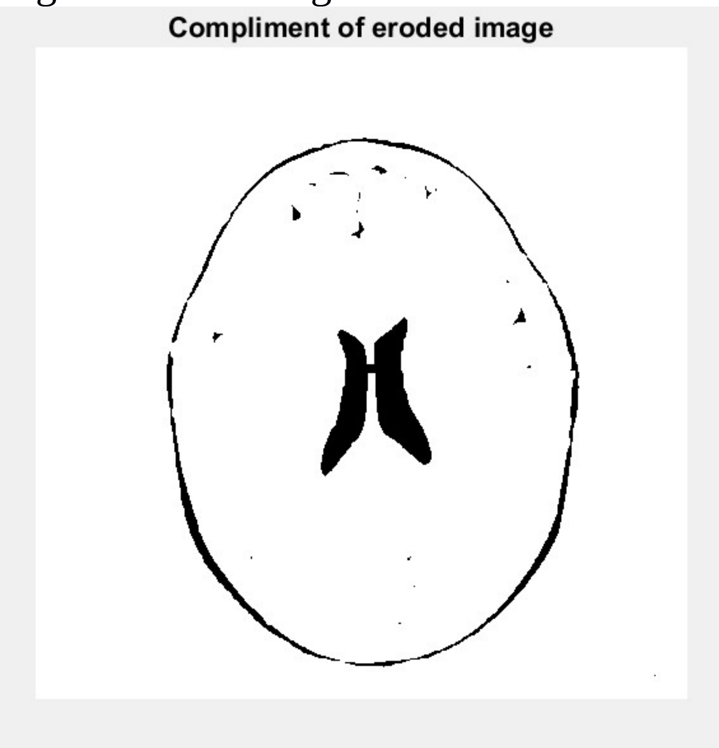

Fig12.Compliment of Eroded Image

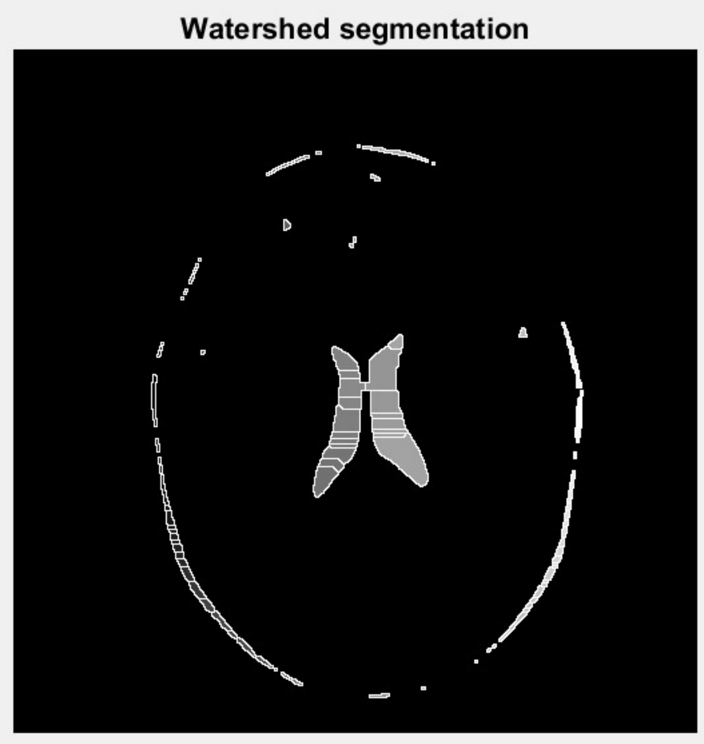

Fig13.Watershed Segmentation

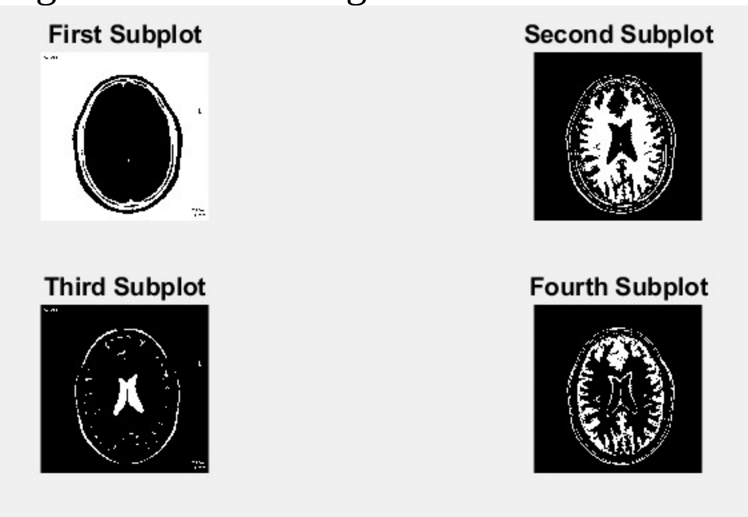

Fig14.K-means Clustering Segmentation

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