Course Report for ‘Digital Image Processing”

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HEMORRHAGIC OR BRAIN STROKE DETECTION

Abstract: The influence and impact on the modern society is tremendous. The rapid advancement of computerized medical image reconstruction, as well as related breakthroughs in analytic methodologies and computer-aided diagnosis, has elevated medical imaging to one of the most significant subfields in scientific imaging. In medical field, when a blood vessel bursts, it leaks blood into the brain, resulting in a hemorrhagic stroke. Because a brain stroke cannot be seen on a CT scan, an MRI is required to complete this application. This approach for removing noise and segmentation is to extract the abnormal region of the picture using Seeded Region Growing algorithms. In real-world applications, the application has an accuracy of 90% to 95%.

Keywords: *Digital Image Processing, Brain Stroke Detection, MRI, Noise Removal, Image Segmentation*

I. INTRODUCTION

Digital image processing has always played a very important role in various fields, including agriculture, medicine, photography, artificial intelligence, etc.

The human brain is made up of 40% gray matter and 60% white matter. The gray matter consists of around 100 billion neurons that gather and send messages, whereas the white matter consists of dendrites and axons that the neurons utilize to convey signals. There are several types of brain diseases: Some of the most common types of brain ailments are infections, trauma, stroke, seizures, and tumors. [1]

A stroke is a sudden interruption in the blood flow to the brain. The majority of strokes are caused by an abrupt obstruction of arteries going to the brain (ischemic stroke). Other strokes are caused by bleeding into brain tissue when a blood artery bursts (hemorrhagic stroke). Stroke is often known as a brain attack since it strikes quickly and requires immediate treatment.

II. DESCRIPTION

In order to remove noise and segment the image, this method extracts the anomalous area of the image utilizing methods called Seeded Region Growing. This project consists of five step modules, each of which will be described below.

A. MODULE DESCRIPTION

1. Image Acquisition:

Images are acquired from Gallery.

2. Preprocessing:

The preprocessing phase's goal is to use potential image enhancing techniques to get the necessary visual quality for the brain picture. The median filter is developed to eliminate noise from brain MRI images.

3. Segmentation:

i. Morphological Operation
ii. Thresholding Method
iii. Seeded Region Growing

i. Morphological Operation:

Morphology is a method for obtaining information from an image that represents and describes the shape of a region. In this study, morphological processes are mostly employed as a filter during post-processing. Boundary pixels and low frequency pixels are removed from the picture as its basic processes. Different images were then produced.

Erosion: Objects in the binary picture are shrunk.
Dilation: the binary image's items expand or enlarge.

ii. Thresholding Method:

When segmenting the stroke in brain MRI images, thresholding is then used. Highlighting pixels in a picture is made feasible via thresholding. Both grayscale and color pictures can be subjected to thresholding. Grayscale graphics are used to illustrate this concept. When adjusting a pixel's intensity value using a reference value, such as the one provided, the low-intensity pixels will become zero and the remainder of the pixels will become one. A binary picture made up of black and white pixels is what the Thresholding process produces.

iii. Seeded Region Growing:

For segmenting brain strokes, the algorithm seeded region growing is utilized. Initial seeds are chosen according to a few characteristics, and the growth process is then segmented by location. A threshold is used to compare the seed pixel to all of its neighbors, and pixels that are higher than the threshold are clustered together to form a single area. The process of expanding an area continues until each region has all of the pixel values. Initial seeds might be a single pixel or a cluster of pixels. We can therefore obtain a segmented picture.

In the end, merge the segmented results of the morphological operation with the SRG.

4. Feature Extraction:

i. Shape Features:

Shape-based image retrieval basically involves comparing how similarly two forms are represented by their characteristics. Shapes may be described using a few basic geometrical characteristics. Simple geometric characteristics are often employed as filters to filter out false positives or in combination with additional shape descriptors to differentiate forms because they can typically only distinguish shapes with considerable variances.

They can't be used as stand-alone shape descriptions. There are several ways to define a form. Center of gravity, Axis of least inertia, Digital bending energy, Eccentricity, Circularity ratio, Elliptic variance, Rectangularity, Convexity, Solidity, Euler number, Profiles, and Hole area ratio are some of the form factors.

5. Classification:

The segmented pictures are used as the basis for the categorization procedure. The use of Support Vector Machine is the primary innovation in this case. The segmented pictures are applied to the SVM classifier, and classification is completed.

Support Vector Machine:

A supervised machine learning approach called "Support Vector Machine" (SVM) may be applied to classification and regression problems. However, categorization issues are where it is most frequently utilized. This approach plots every data point as a point in n-dimensional space, where n is the number of features you have and each feature's value is a specific coordinate value. Then, we carry out classification by identifying the hyper-plane that effectively distinguishes the two classes.

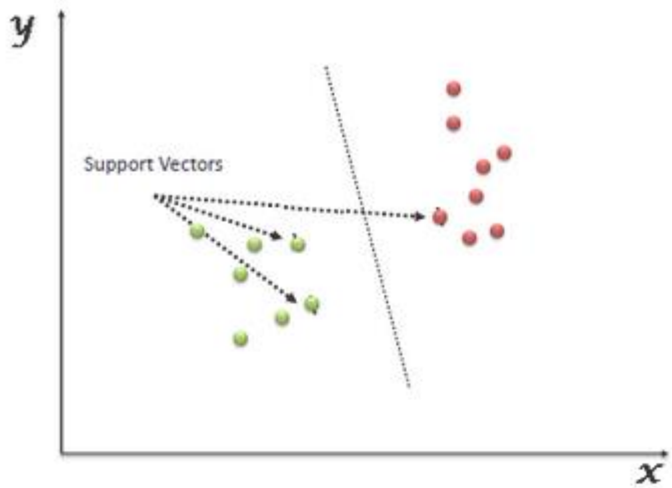


Figure 1: Support Vector Machine Classification

B. ALGORITHMS

This project is divided into two Matlab code files, one named main.m and another named region.m.

main.m

1. Read the image from the the test image folder. The image that can be read is '*.jpg;*.tif;*.png;*.jpeg;*.bmp;*.pgm;*.gif','pick an imgae', therefore the user can pick whatever as desired.
2. The next step is preprocessing the image.
3. Segmentation – Morphological Operation

4. Apply Dilation
5. Apply Erosion
6. Opening image, Opening is a morphological operation that is used to remove small objects from an image. It is a combination of erosion and dilation operations.
7. Closing Image, closing a morphological operation that have perform above.
8. Threshold Method, Image thresholding is a basic but efficient method of dividing an image into foreground and background areas. This image analysis approach is a sort of image segmentation in which objects are isolated by converting grayscale photos to binary images.
9. Segmentation using Seeded Region Growing
10. Apply Classification
11. Apply Classification Using SVM

region.m

This function performs "region growing" in an image from a specified
seedpoint (x,y)

J = regiongrowing(I,x,y,t)

I : input image
J : logical output image of region
x,y : the position of the seedpoint (if not given uses function getpts)
t : maximum intensity distance (defaults to 0.2)

The region is iteratively grown by comparing all unallocated neighbouring pixels to the region.
The difference between a pixel's intensity value and the region's mean, is used as a measure of similarity. The pixel with the smallest difference measured this way is allocated to the respective region.
This process stops when the intensity difference between region mean and new pixel become larger than a certain threshold (t)

1. Output the image
2. Dimensions of input image
3. The mean of the segmented region
4. Number of pixels in region
5. Free memory to store neighbours of the (segmented) region
6. Distance of the region newest pixel to the region mean
7. Start region.m until distance between region and possible new pixels become higher than a certain threshold
8. Add new neighbors’ pixels
9. Calculate the neighbour coordinate

10. Check if neighbor is inside or outside the image
11. Add neighbor if inside and not already part of the segmented area
12. Add a new block of free memory
13. Add pixel with intensity nearest to the mean of the region, to the region
14. Calculate the new mean of the region
15. Save the x and y coordinates of the pixel (for the neighbor add process)
16. Remove the pixel from the neighbor (check) list
17. Return the segmented area as logical matrix

C. SYSTEM DESIGN

BLOCK DIAGRAM

As previously said, the block diagram is quite basic and is separated into five steps: image acquisition, preprocessing with noise reduction, segmentation, feature extraction with shape information (here is where we evaluate the shape of the brain stroke), and classification.

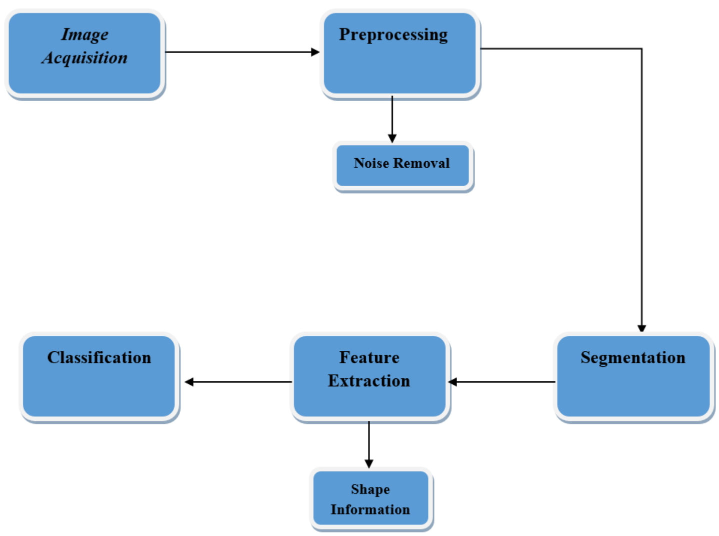


Figure 2: Block Diagram of the program

CLASS DIAGRAM

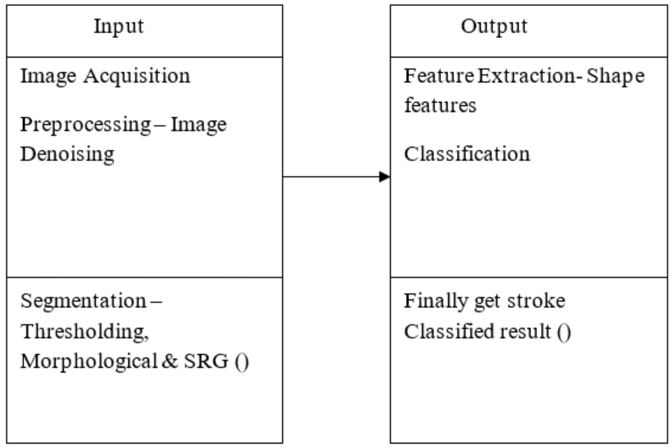


Figure 3: Class Diagram

ACTIVITY DIAGRAM

Activity diagrams are visual representations of the workflows of sequential tasks and operations that provide choice, iteration, and concurrency for this algorithmic study on digital image processing. Activity diagrams may be used to depict the operational, sequential processes of system components in the Unified Modeling Language. The whole flow of control is depicted in an activity diagram.

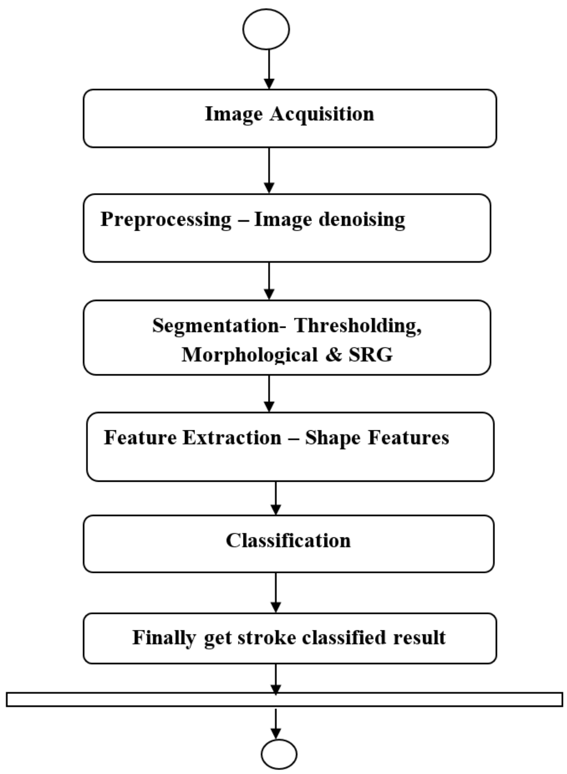


Figure 4: Activity Diagram Flow

D. RESULT ANALYSIS

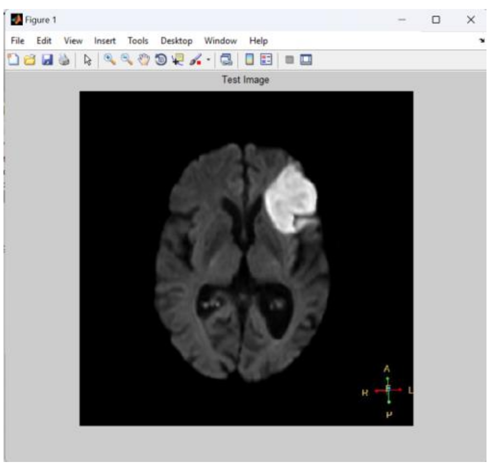
After compiling main.m from the source code folder, we will need to select an image to analyze about the disease of the brain stroke. For this case, I will choose an image first to see how well this program can detect and extract the image. After the program is successfully compiled, Matlab will show about 11 images and one result for the output. With each image, it has its own title and label, which are named Figure 1 to Figure 11, respectively. The process of this application is divided into 3 steps, which are: 1. Image Acquisition and Pre-Processing. 2. Segmentation; 3. Result.

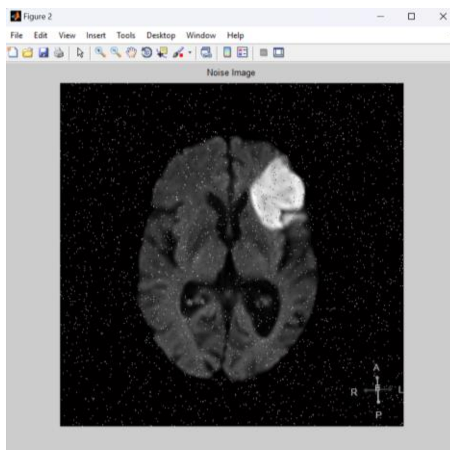
I. It includes 3 images labeled from figure 1 to figure 3 for **Image Acquisition and Preprocessing**:

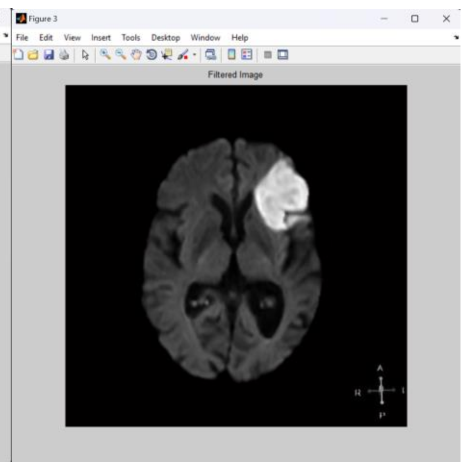
Figure 1: Test Image. It’s the original image, which we have input.

Figure 2: Noise Image, If the image contains noise, as shown below, we will reduce it by using the following function to remove it.

Figure 3: Filtered Image, In this part, we use medfilt2 to remove all the noise from the image, in case you included it from the beginning.







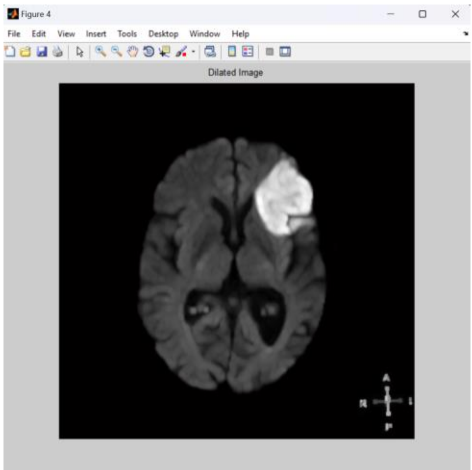
II. **For the Segmentation**, include six images labeled from 4 to 10, respectively:

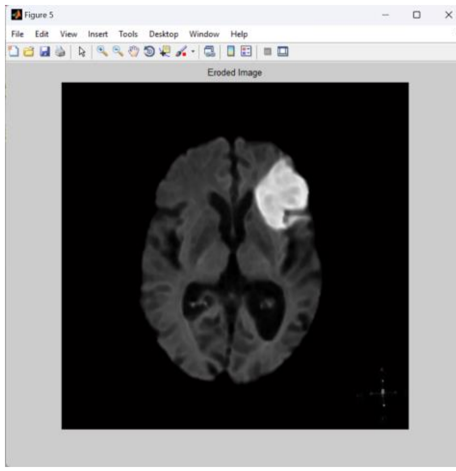
Figure 4: Dilated Image: Objects in the binary picture are shrunk.

Figure 5: Eroded Image. In the binary image, the items expand or enlarge.

Figure 6: Image Opening, Morphological Operation Open.

Opening is a morphological operation that is used to remove small objects from an image. It is a combination of erosion and dilation operations. In this program, the image is first eroded to remove small objects/noise from the image, then dilated to fill in any gaps left from the erosion. The erosion and dilation operations are performed using an nxn window (in this case, a 3x3 window). The program then finds the minimum value in each 3x3 window and stores it in a new image. The result of this operation is an image with the small objects removed.





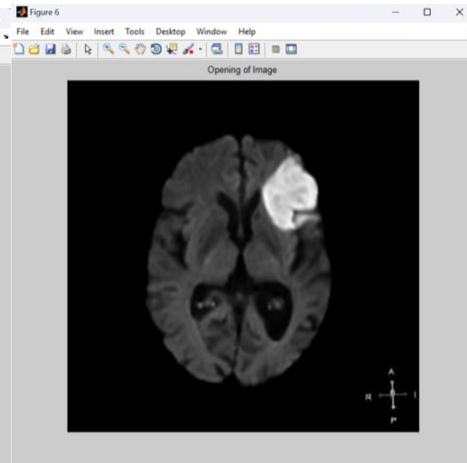


Figure 7: Image Closure, Morphological Operation Closure

Figure 8: Initial Segmented Image, Using the "im2bw" function, create a segmented image, convert it to binary, and remove noise.

BW = im2bw(I,level) converts the grayscale image I to binary image BW, by replacing all pixels in the input image with luminance greater than level with the value 1 (white) and replacing all other pixels with the value 0 (black).

This range is relative to the signal levels possible for the image's class. Therefore, a level value of 0.5 corresponds to an intensity value halfway between the minimum and maximum value of the class. [4]

Figure 9: Image segmentation with Threshold, removal of small objects from the image with bwareaopen, and reduction of unnecessary dots on the image.

BW2 = (BW,P) removes all connected components (objects) that have fewer than P pixels from the binary image BW, producing another binary image, BW2. This operation is known as an *area opening*. [5]

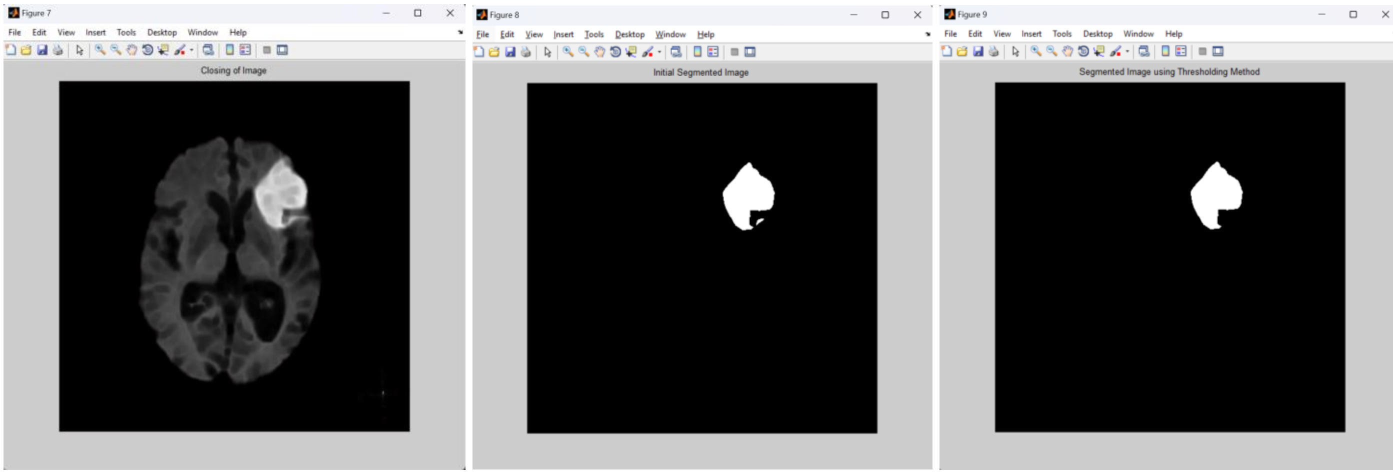
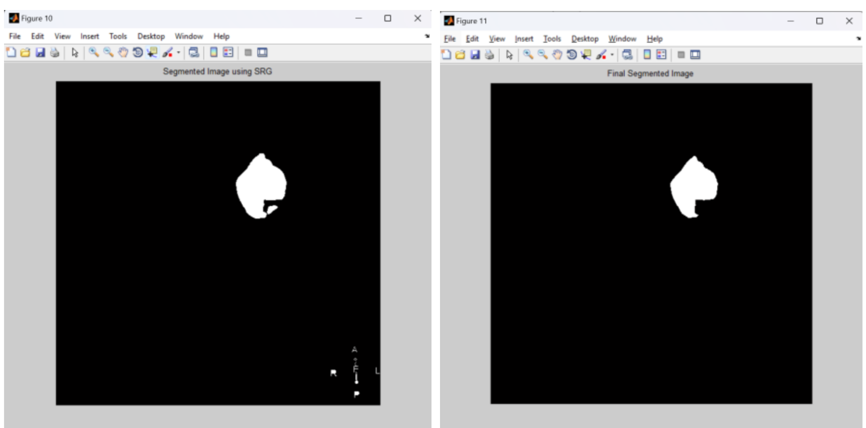


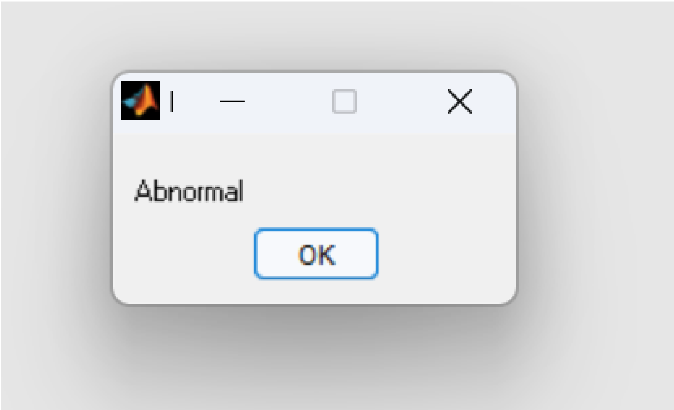
Figure 10: Segmented Image Using SRG, extract the blood clot from the brain, also known as the brain stroke, using the region.m algorithms, which are responsible for comparing all unallocated neighboring pixels to the region.

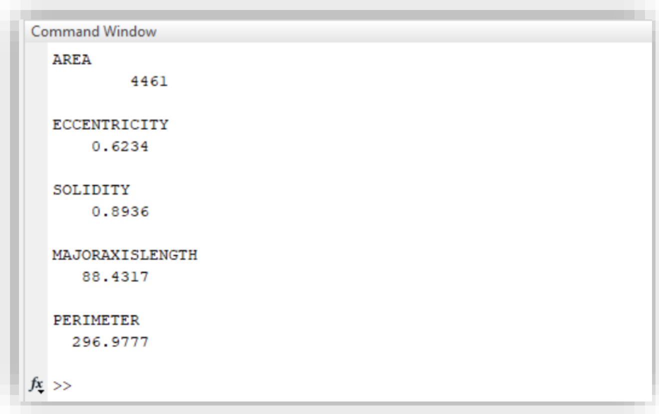
Figure 11: Final Segmented Image. Reduce the noise that is not part of the brain stroke and extract only the real one.



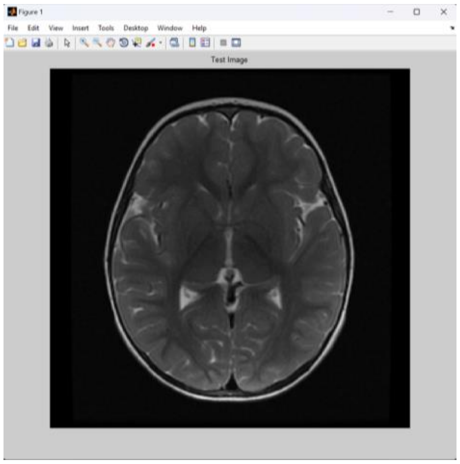
III. **For the result**, it includes only 1 image and 1 description about the result in detail, such as the area of the extracted segmentation, eccentricity, solidity, major axis length, and perimeter. All these 4 function is all use a built in function from the Matlab which is as know as regionsprops.

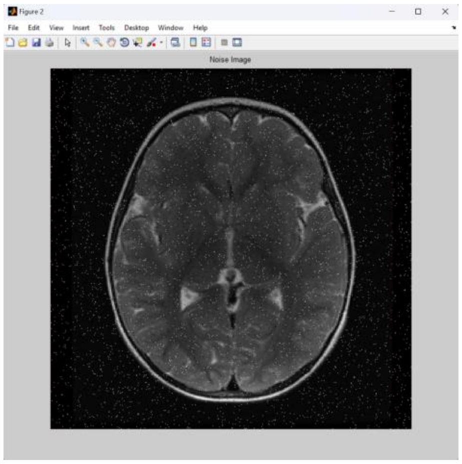
stats = regionprops(BW,properties) returns measurements for the set of properties for each 8-connected component (object) in the binary image, BW. We can use regionprops on contiguous regions and discontiguous regions. regionprops measures a variety of image quantities and features in a black and white image. Specifically, given a black and white image it automatically determines the properties of each contiguous white region that is 8-connected. One of these particular properties is the **centroid**. [6]

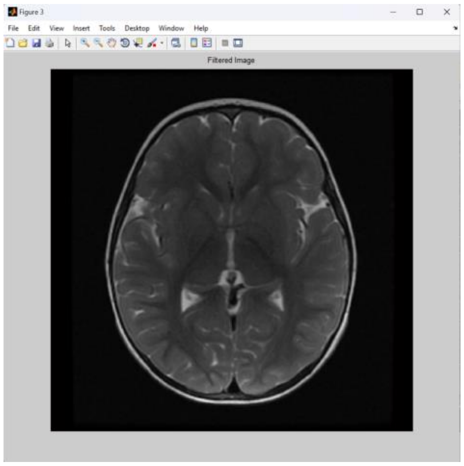


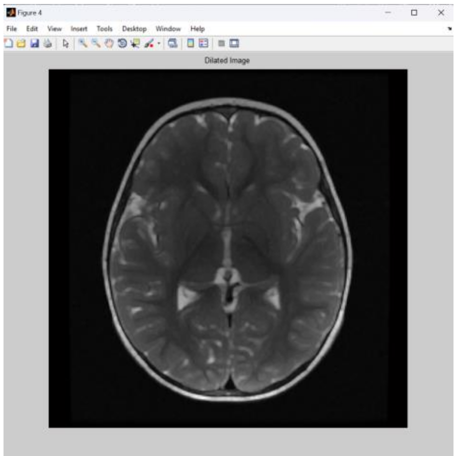


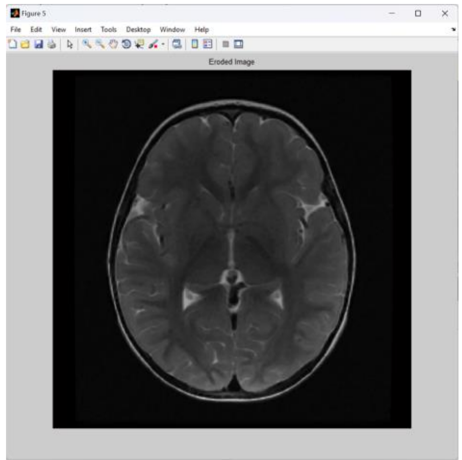
The figure below shows the second case of the brain, which has the result "normal." The procedure of the algorithm we mentioned above will be repeated, but the only difference we have seen is the result of the image we obtained.

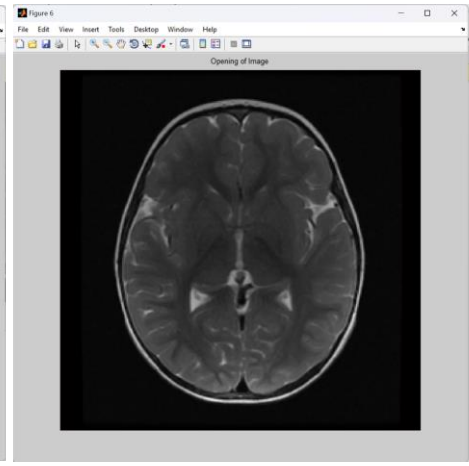


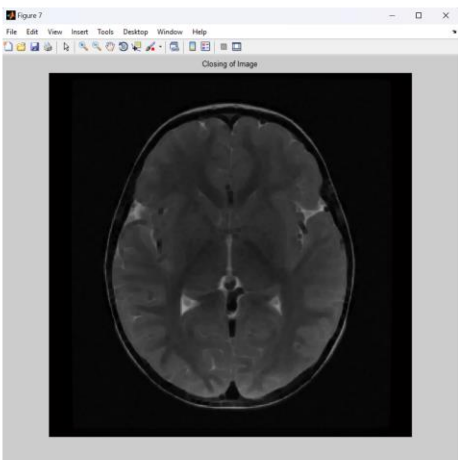


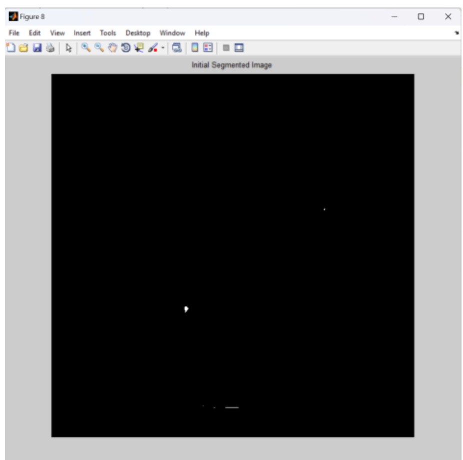












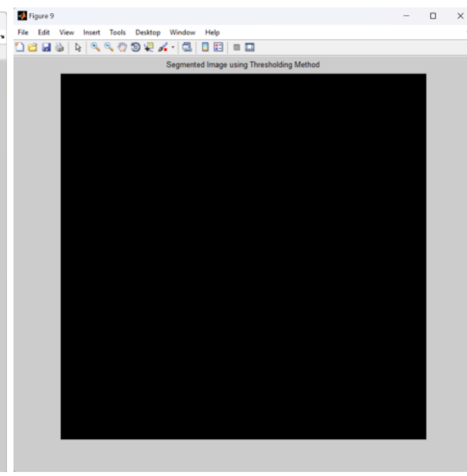
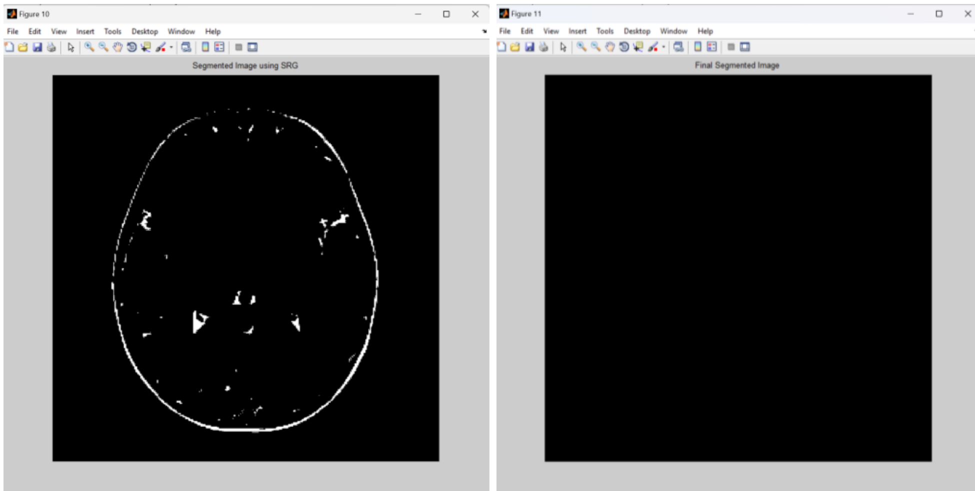
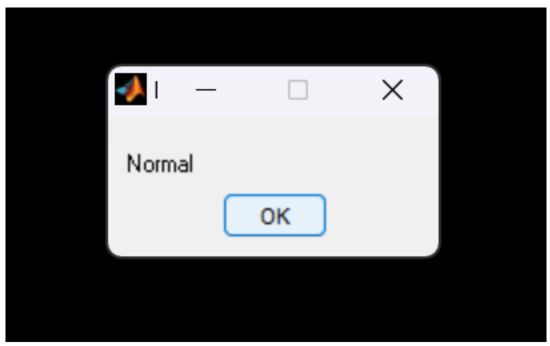


Figure 10 shows that the image has been filtered so many times that it now only contains white dots. This is when the algorithm in Figure 11 becomes important. Otherwise, we will get confused and think that all the white things in the image are a blood clot or a stroke when they are actually not. Last but not least, when we look at the figure 11, We will notice that the image is totally black because no blood clot was detected, which is 100% success.



Moreover, we will get a notification on the screen of the result showing that the result is very normal and we don't need to do the regionprops to analyze the area of the blood clot, perimeter, etc.



E. SYSTEM STUDY

PROPOSED SYSTEM:

- The automated technique (detection) of brain tumors by MRI is known as a Computer-Aided Diagnosis (CAD) system. The CAD system can give very exact reconstruction of the original picture, hence providing the valuable perspective and accuracy of early brain stroke detection.
- Preprocessing, segmentation, feature extraction, and classification are the four fundamental processes in our proposed approach.
- The median filter is used in preprocessing to reduce noise from images.
- To recover the stroke region from MRI data, image segmentation methods such as thresholding and seeded region growth are utilized.
- Following that, feature extraction is carried out. Shape feature description is used.
- Finally, classification is offered as a method for distinguishing the hemorrhagic region from normal tissue.

ADVANTAGES OF PROPOSED SYSTEM:

- The suggested method detects brain strokes well.
- It is a very accurate reconstruction of the original picture.
- It effectively eliminates noise from the image.

III. CONCLUSION

This study presented a procedure for the segmentation of medical brain stroke images consisting of stroke. Brain stroke segmentation is a complicated process which consists of many different steps for segmentation process, including Morphological and Seeded Region Growing. MRI images are the best choice to study stroke in Matlab program because MRI device provides clear images with more details for the brain. These methods are able to detect several kinds of strokes in several positions in the brain. As an future of Computer Scientist and I hopes this project helps physician to detect the brain strokes in MRI images.

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REFERENCES

[1] Question and Answer about the Brain.

https://uvan.heroinewarrior.com/is-a-neuron-a-nerve-cell-5150277

[2]Advanced Morphological Technique for Automatic Brain Tumor Detection and Evaluation of Statistical Parameters. Advanced Morphological Technique for Automatic Brain Tumor Detection and Evaluation of Statistical Parameters - ScienceDirect 2016. https://www.sciencedirect.com/science/article/pii/S2212017316302420 (accessed December 17, 2022).

[3]Xiao J, Mo M, Wang Z, Zhou C, Shen J, Yuan J, et al. PubMed Central (PMC) 2022. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8900909/ (accessed December 17, 2022).

[4]Convert image to binary image, based on threshold - MATLAB im2bw. Convert Image to Binary Image, Based on Threshold - MATLAB Im2bw n.d. https://www.mathworks.com/help/images/ref/im2bw.html (accessed December 17, 2022).

[5] Remove small objects from binary image - MATLAB bwareaopen. Remove Small Objects from Binary Image - MATLAB Bwareaopen n.d. https://www.mathworks.com/help/images/ref/bwareaopen.html (accessed December 17, 2022).

[6]Measure properties of image regions - MATLAB regionprops. Measure Properties of Image Regions - MATLAB Regionprops n.d. https://www.mathworks.com/help/images/ref/regionprops.html (accessed December 17, 2022).