

Digital Processing for Computed Tomography Images: Brain Tumor Extraction and Histogram Analysis

Rania Hussien Al-Ashwal, Eko Supriyanto, Nur Anati B Abdul Rani, Nur Azmira B Abdullah, Nur Illani B Aziz , Rania B Mahfooz

IJN-UTM Cardiovascular Engineering Centre, Clinical Science Department, Faculty of Bioscience and Medical Engineering
University Technology Malaysia
V01, FBME, Skudai, 81310, Johor
MALAYSIA

drrania@biomedical.utm.my, Eko@utm.my <http://www.utm.my>

Abstract: - Computed Tomography is one of the modalities that can be used to diagnose brain tumor. However, this modality only capturing the image without extracting the tumor completely. The process of extracting medical images is the most challenging field nowadays. Most of the technique used is more on MRI modality compared to CT images because it is higher resolutions. This project described two methods the detection and extraction of brain tumor from patient's CT scan images of the brain from two brain tumor patients. Image segmentation used to detect the tumor. The process involves the extraction and segmentation of brain tumor from CT images of a male patient using MATLAB software. The severity of the tumor automatically determined by measuring the volume. Histogram analysis used to detect the level of the tumor depending on the difference in color intensity for different object density in the image.

Keywords: - Component; Computed Tomography; Segmentation; Volume Measurement; Tumor Extraction; Image Processing

1 Introduction

Brain is the most important part of our body that control our daily activities. It controls the spontaneous activities like breathing and directs the activities that we want to do like walking and talking. The brain is the controller of the human system. Human brain is the most complex living organs. Studies related to human brain have been extensively growing to discover numerous fundamental questions regarding its development, vital functions and how to prevent brain disorders [1].

Brain cancer can be counted among the most deadly and obstinate diseases [2]. Tumors are defined as the abnormal growth of the tissue. Brain tumor can be specifically defined as the abnormal mass of tissue in which the cells grow and uncontrolled cell multiplying, seemingly abandoned by the mechanisms that control the normal cells [3]. In addition to that, the conventional definition of brain tumor includes neoplasms originating from brain parenchyma as well as from meninges and even tumors of the pituitary

gland or of osseous intracranial structure that can indirectly affect brain tissues [4]. Figure 1 shows the basic anatomy of the brain.

Brain tumor occurred when the cells were dividing and growing abnormally. It is appear to be a solid mass when it diagnosed with diagnostic medical imaging techniques. There are two types of brain tumor which is primary brain tumor and metastatic brain tumor. Primary brain tumor is the condition when the tumor is formed in the brain and tended to stay there while the metastatic brain tumor is the tumor that is formed elsewhere in the body and spread through the brain [5].

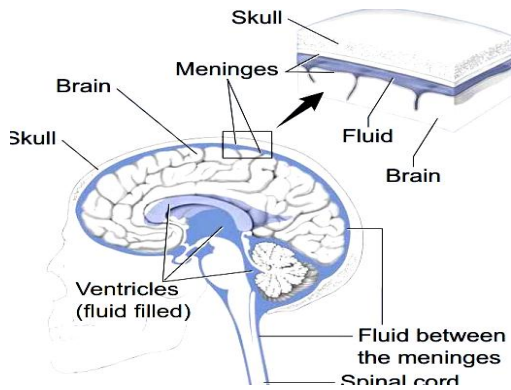


Figure.1 Brain Anatomy (adapted from National Cancer Institute,US).

Tumor in the brain can be classified into benign and malignant. Benign appear to be slightly same as normal cell but it is will growth in a very slow speed. Usually benign can be removed by surgical but it also have possibility to growth again [6]. However, benign also can be growth as malignant which is consists of cancerous cells. Malignant is the rapid growing tumor which is invasive and life threatening. It is also called as brain cancer since the malignant contains cancerous cells that able to destroy any nearby cell [7].

The symptom having of brain tumor depends on the location, size and type of the tumor. It occurs when the tumor compressing the surrounding cells and gives out pressure. Besides, it is also occurs when the tumor block the fluid that flows throughout the brain.

The common symptoms are having headache, nausea and vomiting, and having problem in balancing and walking. Brain tumor can be detected by the diagnostic imaging modalities such as CT scan and MRI. Both of the modalities have advantages in detecting depending on the location type and the purpose of examination needed. In this paper, we prefer to use the CT images because it is easy to examine and gives out accurate calcification and foreign mass location. Figure 2 shows the CT scan image of normal brain Where no abnormalities on the brain cross section. The lateral ventricle form symmetrically for both hemispheres.

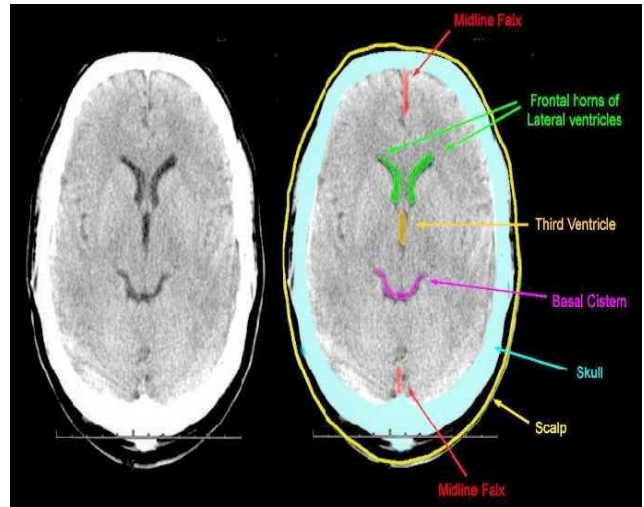


Fig.2 Normal brain CT image. (Adapted from (<http://www.crash.lshtm.ac.uk>.)

In most cases, the tumor will gives out pressure on surrounding tissue and make the ventricle covered with the tissue. This can be seen on Figure 3 in which the CT image of patient with tumor in the brain. The patient's image shows clear tissue pressure which has covered the ventricle in the left hemisphere. The tumor formed the solid mass on at the cerebrum hemisphere.

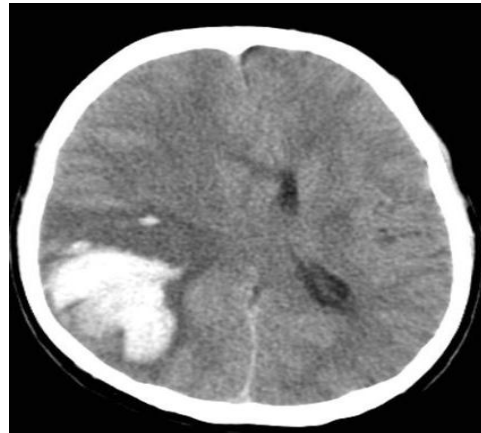


Fig. 3 Solid mass formed at the cerebrum hemisphere that classified as tumor.

The CT image acquired from the CT machine give two dimension cross sectional of brain. However, the image acquired did not extract the tumor from the image. Thus, the image processing is needed to

determine the severity of the tumor depends on the size.

The processing also will be able to calculate the area and the volume of the tumor automatically. According to Brunetti et. al, early detection and characterization are still issues in diagnosing brain tumors and considered as challenging. The existing method used in brain tumor image processing is based on the thresholding and region growing ignoring the spatial characteristics that is important in malignant tumor detection [8]. CT is widely used in radiation oncology clinics [9]. CT scan is chosen in most clinical examination because it is non-invasive and painless [10]. The computerized tomography is found to be the most reliable method for early detection of tumor because CT images contain anatomical information which offers the possibility to target only the tumor [11].

CT is also routinely used for the detection and assessment toward intracranial tumor as well as the secondary tumors. Besides, CT has permitted both visualization of brain tumors and its normal surrounding. CT has also provides more solid basis for histologic characterization and the treatment selection [12].

CT has several advantages over magnetic resonance imaging (MRI) which includes short imaging times, widespread availability and ease of access [13]. Different imaging techniques have their own advantages and disadvantages. All imaging modalities have the ability in providing functional information depending on how the images are being processed. The purpose of segmentation involved in this study is to analyse the different elements included in the brain and tumor is extracted to determine the

CT scan has advantages upon MRI as it will allow accurate detection of calcification and solid foreign structure. Besides that, it is low in cost and faster when compared to MRI. CT scan providing an image with grayscale color. The tumor can be differentiated by comparing the grey level of the CT scan image. However, the CT scan machine only scanning and gives the cross-sectional image without the complete extraction of the brain tumor.

The image processing is needed to extract the tumor from the original image. Besides that, the different intensity of the tumor will give different stage of tumor that the patient had. The problem can be overcome with the image processing technique that automatically

extract and create histogram. After that, the area of the tumor will be calculated. This image processing will be programmed using MATLAB software.

Image segmentations are usually the technique used to separate different region of brain image. The brain cross sectional image from MRI modality was first segmented the tumor region and pixel intensity was studied [14]. The FFT window techniques were used to identified the tumor and its level of activeness. While in other study image enhancement was used to increase SNR ratio by modifying the colour intensity of image.

This technique used both linear and non-linear filtering method. In order to extract the brain tumor from the image acquired from imaging modalities, MATLAB image processing tools such as noise removal function, some morphological technique and segmentation algorithm that were essential for extracting the tumor. This technique also agreed by [15] that the basic technique used was segmentation and morphological technique.

Histogram contains intensity value of 0-255. The zero value is the darkest part while the 255 was the white or the brightest side. Using the histogram analysis approached [16] used the mixture Gaussian filter for the extracted part pixel intensity.

Using same concept but with different approach. However, most of the technique used is more on MRI modality compared to CT images because it is higher resolutions. CT images of human body parts help medical doctors in diagnosing illness like brain tumor, colon cancer, lung cancer and so forth. However, it is quite difficult to obtain the important features in the images because it is limited by the image processing level and also doctor's experience [17].

This project particularly focuses on the techniques and appropriate filter used in segmenting and extracting brain tumor from CT images. In this paper, our focus was on Image pre-processing. The image loaded into the MATLAB program. It is then converted from RGB image to grayscale image. The size of the image will be resized to 256x256. By using complement image, the image was then enhanced and histogram was obtained using specific MATLAB script. Binarization and thinning is done to reduce the noise and obtained the lower intensity image. Finally, the edge detection technique was used to the thinning image to differentiate the edge of the different intensity image.

2 MATERIAL AND METHODOLOGY

2.1 Image data

The image of brain tumor is obtained from the 10 of CT images of a male patient. The images are then being evaluated and ten images are chosen where the tumor is assumed to present in that particular area. The image selected is based on the difference between the normal brain CT image and the abnormal brain.

2.2 Image acquisition

Images from the two patients were compared to the normal CT image as shown in Figure 4. After identifying the abnormalities on the brain tissue, 18 images that contained tumor were selected to do feature extraction. The images acquire was grayscale in color that consist of intensities range from 0 to 255. The images were stored in the same folder to do MATLAB image processing. The initial format for the CT images used on MATLAB was JPEG. Figure 5 show the flow chart for the image processing.

Image processing phase in this paper proposed the used of the segmentation level technique. Mask will be added to the image acquired after the pre-processing phase. The segmented level will be extracted and the area of the tumor will be calculated automatically after the mask is added. Second stage of the processing phase is to plot the graph of area versus length.

This stage is important to measure the corresponding volume of the tumor. The volume of the tumor can be calculated by determining the area under the graph. It is also can be shown in the equation 1 and the $f(x)$ is the area.

$$Volume = \int_A^B f(x) dx \tag{1}$$

This equation is used when the graph plotted is showing curve line as shown in Figure 6.

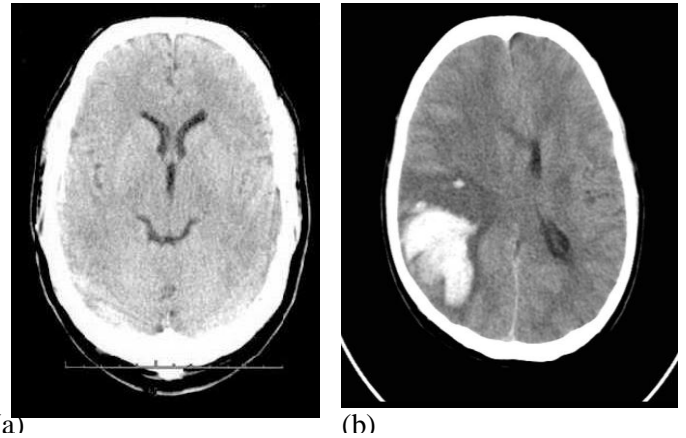


Fig.5 (a) Normal CT image of brain (Adapted from <http://www.crash.lshtm.ac.uk/ctscanlarge.htm>) (b) Abnormal tissue identified and foreign mass shows on the parietal lobe of the cerebrum.

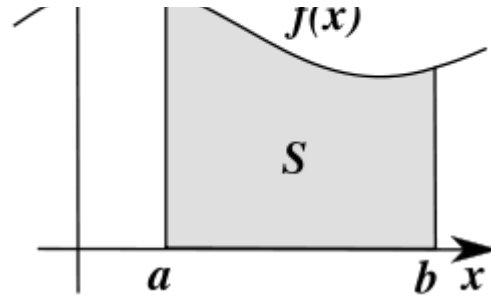


Fig.4 Graph that predicted to be the result.

This segmentation technique give advantages as it will automatically calculated the volume of the tumor which is significant to the level of severity of the tumor. Besides that, the operator did not need to measure volume of the tumor separately. However, this segmentation technique have still have disadvantage. The area calculated is only the approximate area for corresponding masking level. It means when determining the area, masking level should be appropriate mark at the image.

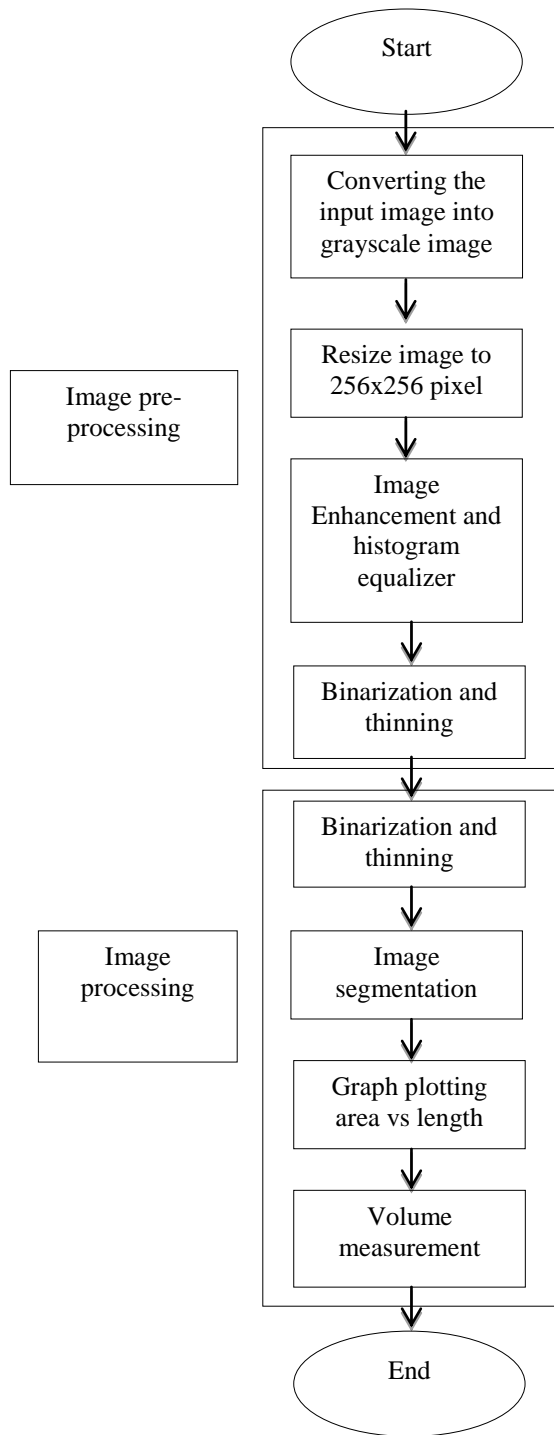


Fig.6 Image processing flow diagram used for histogram and segmentation methods

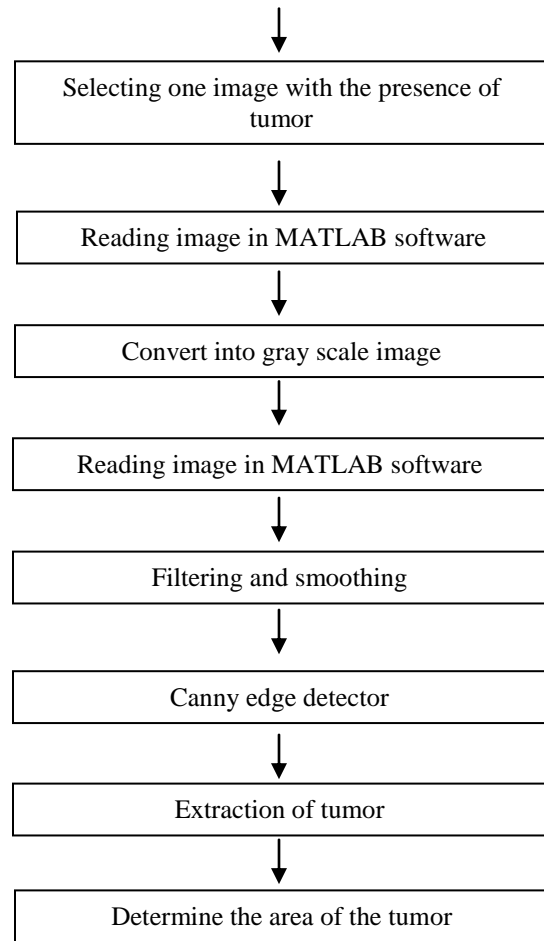


Fig.7: Image processing flow diagram used for canny edge detection segmentation methods

2.21 Canny edge detector and output extraction

Canny is the most effective and famous edge detector for the segmentation [17]. There are three steps involved in canny edge detector. First is noise removal, second is gradient computation and third is edge tracking. Refer to Figure11 for the result of segmentation by using canny detector.

A blurred image or unclear image will be produced if the image is convolved with the Gaussian filter [18]. Therefore median filter is commonly used since it effective in removing the noise and produced a clearer image [19]. Figure 4 shows the different types of filter used to filter the noise. From figure 2(b), we can see that media filter is the best filter used to eliminate the noise [20].

Images form CT data



Fig.8 Segmentation of the brain tumor by using canny edge detector(adapted from *International Conference on Advances in Engineering, Science and Management, 2012*).

Then, the cropped image is converted to binary image by using appropriate threshold value.

3 RESULTS AND DISCUSSION

3.1 Histogram

The histogram in Figure 11 is intensity for y-axis and pixel value for x-axis. The different intensity of tumor for each layer of 13 slices for patient number 2 is between 0 to 100 pixels. If the tumor become larger each layer, the intensity rose up and then become decrease due to size. The location of tumor is in between parietal lobe, occipital lobe and temporal lobe. Parietal lobe associated with movement, orientation, recognition and perception of stimuli. Then, occipital lobe associated with visual processing and temporal lobe for perception and recognition of auditory stimuli, memory and speech. There is possibility that this patient have some effect due to this tumor like problem with visual, movement and memory.

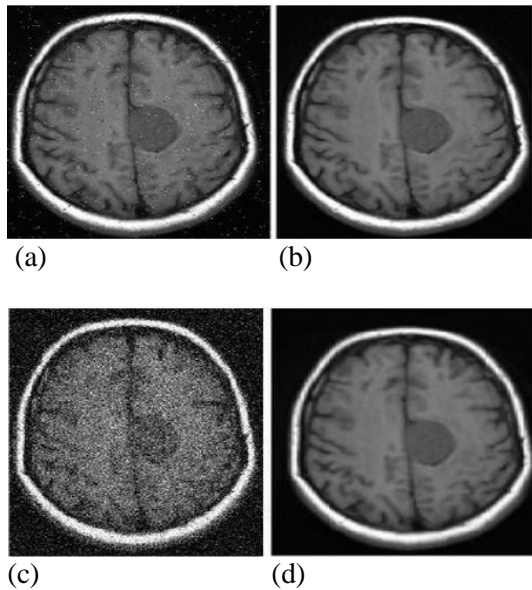
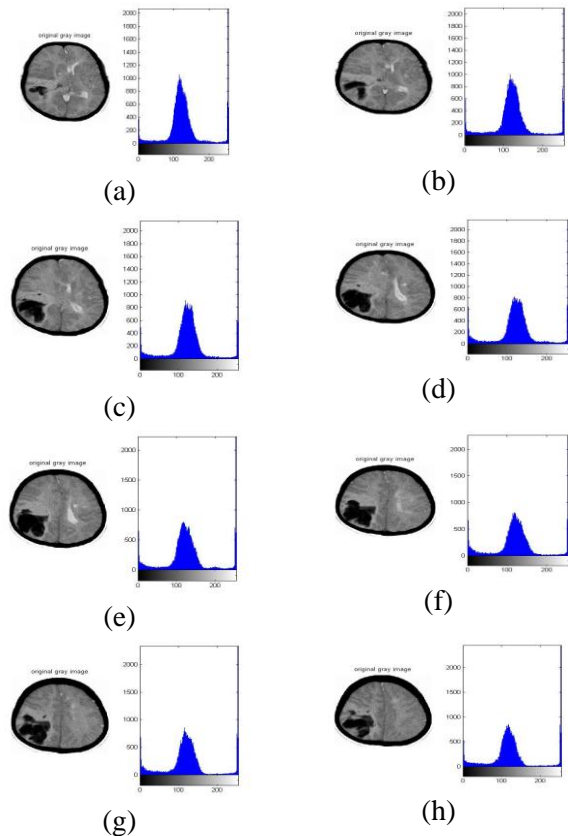


Fig.9 (a) Original image (b) Median filter (c) Gaussian filter (d) Linear filter (adapted from *J.selvakumar conference journal,2012*)

2.22 Extracting the tumor

The tumor is extracted by using submatrix operation in cropping method where we need to select two edges to form a rectangle in the appropriate tumor region.



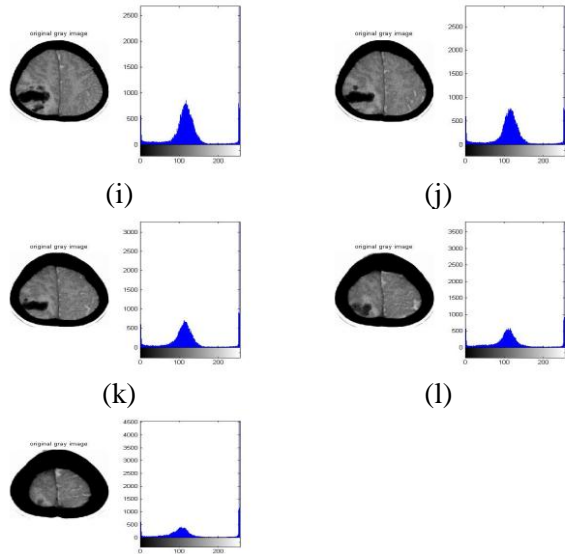


Fig.10 The histogram of difference sizes of tumor each layer.

The histogram technique also used to differentiate between the hemisphere which contain the tumor and not contain any abnormalities. The histogram shows different intensity as shown in Figure 11. The binarization is one of the pre-processing phases in this project image processing. In binarization, the last four images did not show any result due to the intensity of the image increase. Besides, it is also caused by the size of the tumor which is become smaller as the sliced going deep to the end of the brain. This result is shown on Figure 12.

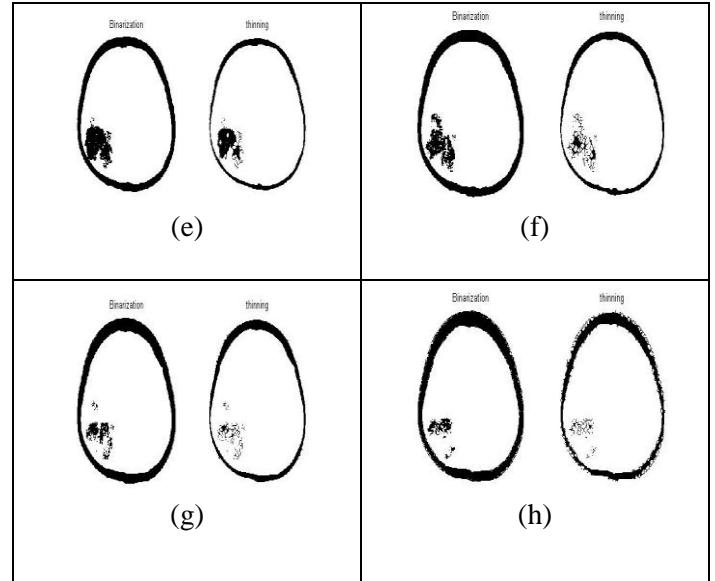
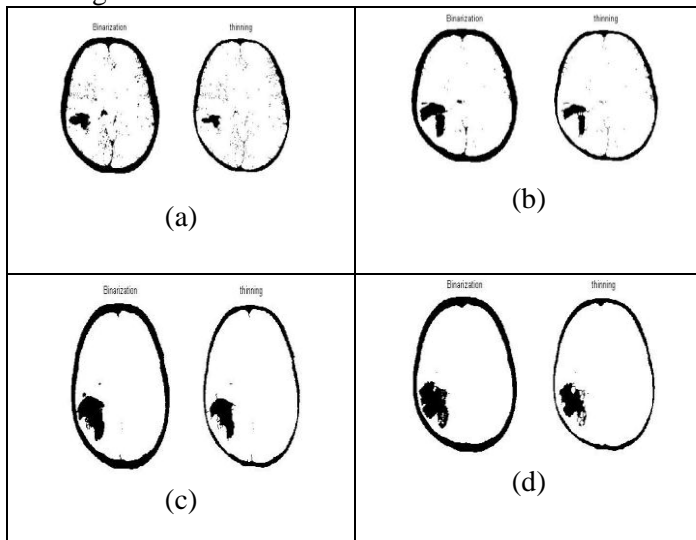


Figure.11 Binarization and thinning for each slice

Segmented part shows similarity when used with 25 iteration method. Figure 13 shows the segmented part of the tumor, the peak is represent the largest tumor from thirteen slice of section view and also can calculate the volume of tumor in the brain by using equation 1 . The volume of the tumor in these cases was approximately 873850 cubic pixels. Segmented part shows similarity when used with 25 iteration method. Figure 13 shows the segmented part of the tumor.



Figure.12 Tumor Segmentation

2.23 Tumor extraction and segmentation

This section explains the result of the images patient number two after they have been through a few steps of image processing technique. The analysis is done by using a CT image of brain tumor for 8 slices.

The segmentation and the extraction of the brain tumor are obtained. Figure 14(a) shows the original image of the brain tumor. The noise in the image will then be filtered by using median filter. As mentioned before in the literature review, median filter is the best

since it completely remove the noise and smoothing the image. Figure14(b) shows the filtered image.

Canny edge detector was used to segment the image. This segmentation method is the most effective segmentation and easier to obtained parts in the image. The segmentation of the brain shown in Figure14(c).

To extract the brain tumor, cropping method was used. The tumor will be cropped and convert the image to binary by using appropriate threshold value. Then, the area of the binary image was calculated. Figure 14(d) shows the cropped tumor, meanwhile Figure 14(e) shows the binary image of the tumor. The same process was used to extract the brain tumor for other slices of image, it s clear from the comparison between 8 slices that the size and the shape of the tumor is different in each slice.

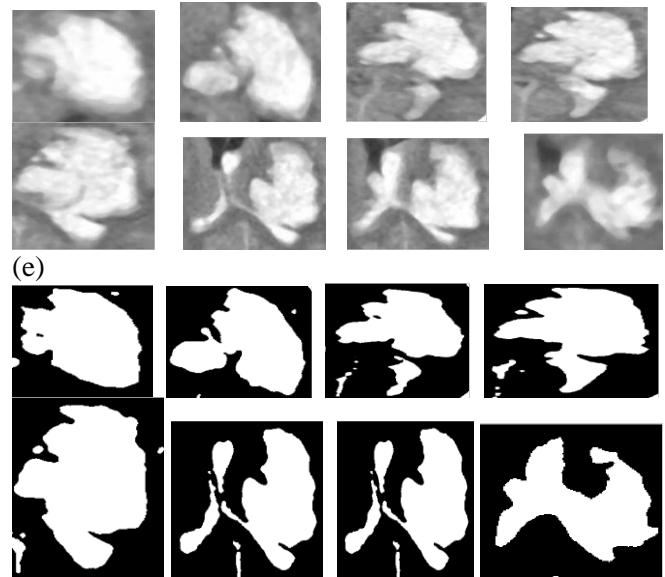
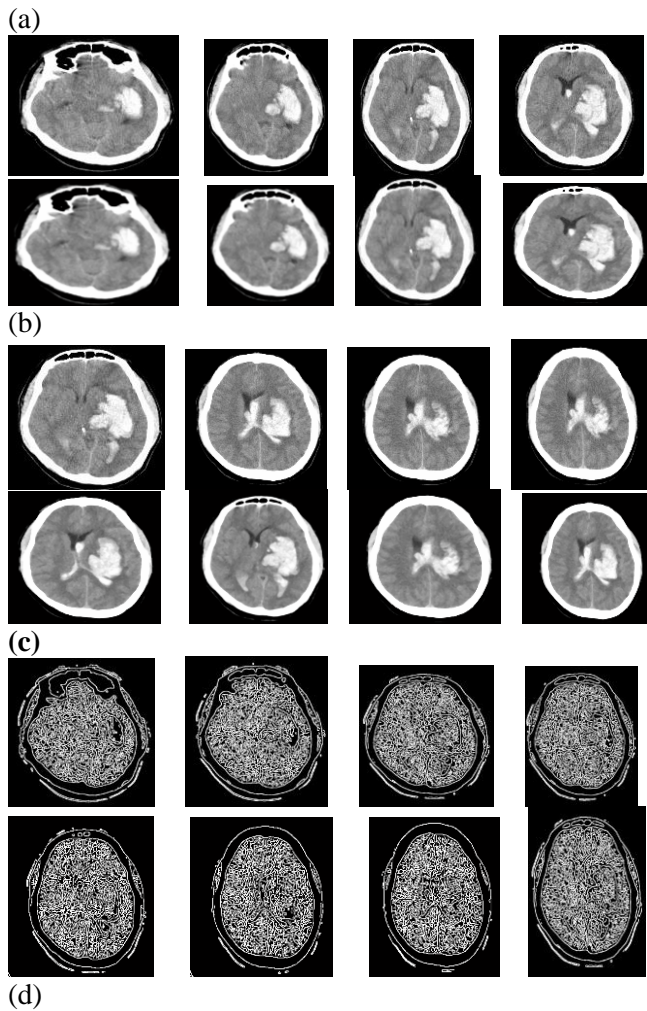


Fig.13 Segmentation and extraction for 8 slice; (a) Original image, (b) Filtered image, (c) Segmented image, (d) Cropped brain tumor, (e) Brain tumor extraction.

3.3 Size of the tumor

From the extracted image, the area of the tumor was obtained.

Table 1 show the area of the tumor in different slices.

Slice	Area
11	8.9014e+003
12	1.4411e+004
13	1.8806e+004
14	2.0301e+004
15	1.9450e+004

16	2.0779e+004
17	1.9624e+004
18	1.5091e+004

4CONCLUSION

In this project, the extraction of the tumor and the size of the interested tumors successfully obtained through a few steps in the MATLAB coding for image processing.

We were also able to segment the different part of the brain from the brain CT mages. By calculating the area, we can know that there are slight differences between the sizes of the tumor for different slice of brain images.

The tumor was successfully extracted from the image using segmentation processing algorithm. Besides, the volume of the tumor can be calculated after the segmentation had been done but still need mor testing on the accuracy . This technique can make the operator or medical doctor easier as it would determine the level of the tumor growth instantaneously.

Compared to other research, this technique is much easier to use on CT scan image. Most of the processing of the brain tumor before was focused on the MRI image which is higher resolution. Thus, the technique suggest on this project provide an alternative to make used of CT images of brain specifically.

For the future works, it is recommended to find the error percentage for the volume calculated. Besides, some improvement should be made to increase the accuracy of the area calculated.

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