DETECTION AND EXTRACTION OF HUMAN BRAIN TUMOR FROM MRI IMAGE USING IMAGE PROCESSING TECHNIQUE

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Abstract

The Magnetic Resonance Image (MRI) is usually associated with impurity and noise that should be removed by the application of image processing technique.

In this study, four stages of image processing technique have been used. At the preprocessing stage, the MRI image was converted to grayscale and the noise was decreased by using a high pass filter. At the enhancement stage, an anisotropic filter was applied to the image to improve the MRI contrast and to remove the noise. At the segmentation stage, the threshold algorithm was used to segment the MRI image. The final stage was applying the morphological operation to the segmented image which allowed the detection and bounding of the tumor in a pure form, as well as forming the contour around the tumor region and thereby separating it from the brain. The area and the execution time of each tumor studied were calculated. When there was no tumor on the MRI image of the brain, the morphological operation provided a sign of its absence. In this study, MATLAB2015a was applied to all stages of image processing technique.

Keywords: MRI; Image Processing; Human Brain Tumor; Thresholding; Segmentation.

Introduction

In recent years, brain tumor has become one of the most common diseases in the world. It is one of the major causes of an increasing mortality rate for both adults and children (Debnath and Tai, 2011). The National Brain Tumor Foundation (NBTF) found that the number of people dying from this disease had been increasing. Brain tumors are formed when the cells divide and grow abnormally forming masses of abnormal tissue inside the skull that attacks brain nerves and other surrounding tissue of the brain (Sidra et al., 2019).

A tumor that initiates from a cell or group of cells in the tissues that cover the brain is referred to as a primary tumor. While the secondary or metastatic tumor originates from the tissue of other parts and spread over the brain (Debnath and Tai, 2011).

Tumors are also classified according to certain factors such as origin, growth pattern, and malignancy into three types.

1- Benign Tumor is a kind of tumor that doesn't contain cancer cells and can be easily removed. This tumor can cause a serious problem when suppressing the sensitive area of the brain (Chaudhari et al., 2021).

2- Pre-malignant Tumor is a pre-cancer stage maybe grow into cancer (Akanksha and Hemalatha, 2020).

3- Malignant Tumor is a type of tumor that grows worse with time, ultimately resulting in the death of a person (Chaudhari et al.2021). A malignant tumor can be a primary type that originates from brain tissue or metastatic area from another tumor in the body, it grows rapidly and attacks the nearby healthy brain tissue (Akanksha and Hemalatha, 2020).

The diagnosis of a tumor is usually done by either Computed Tomography (CT) scan or Magnetic Resonance Image (MRI). MRI is preferred over CT scan because it does not contain any radiation and provides a better visual anatomical structure of tissue than CT (Umit and Ahmet, 2017). Additionally, MRI shows the internal structure of the body, which enables the comparison between normal tissue and abnormal tissue in any part of the body (Akanksha and Hemalatha, 2020).

MRI produces images with a fraction of noise and high resolution in the resulting image. To improve the accuracy of image analysis, removing this noise is a necessary step (Alexander et al., 2018). The widely used image processing technique is to convert the MRI image into a digital form through the application of an Efficient Algorithm to the input image, to achieve a high-quality image of the detected tumor (Anurag and Manish, 2020).

Different methods are used to extract and detect tumor from MRI image depending on the strategy of the researcher, for instance, Chaudhari et al., (2021) detected and extracted the brain tumor from MRI image through the following stages: pre-processing, histogram equalization, watershed segmentation, and morphological operations. While Sravanthi et al., (2021) proposed a method to detect and identify a brain tumor from MRI image through image segmentation process and applying a variety of image filtering techniques to determine image characteristics. However, Akanksha and Hemalatha (2020) have detected, extracted, and analyzed the data through minimizing the time spent on the process after applying the following steps: threshold segmentation, watershed segmentation, and morphological operations. Faraz (2019) described how to detect, specify, and highlight tumor location by using thresholding, erosion, anisotropic filtering, and MATLAB GUI. Amit and Patil (2019) have detected the brain tumor from MRI image by using four stages of image processing technique which are pre-processing, image segmentation, feature extraction, and image classification. They found that the execution time for the watershed and K-means methods is less than the other segmentation algorithm. For the detection of human brain tumour, Digvijay et al., (2018) proposed two types of algorithms namely K-means and clustering Algorithms, to separate the tumour and the brain by using morphological operations. This process produces high-quality images.

In this study, the image processing technique was used to detect and extract human brain tumor from MRI image through four stages: preprocessing, image enhancement, segmentation, and morphological operation. The tumor's size, shape, and location were determined, as well as the execution time of the process.

Methodology

Medical analysis and image processing technique has been used for detecting and extracting the tumor from human brain MRI images which were gotten from Kaggle. Kaggle is an open-source dataset. The images size were 240*240 pixels. MATLAB program was used to fulfill the stages of image processing. The flow chart is shown in Figure (1).

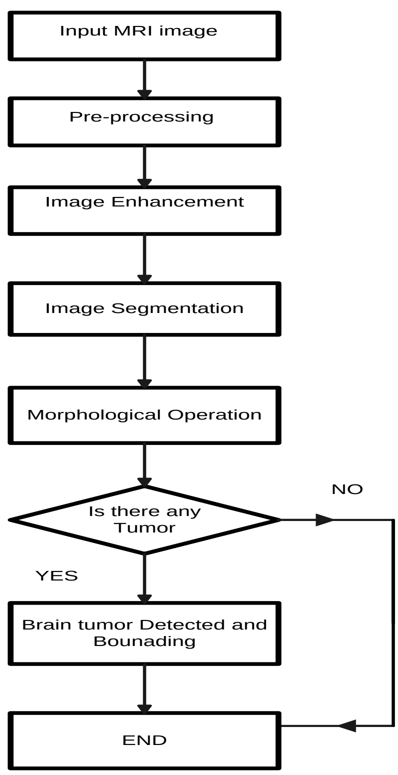


Figure (1): The Stages Sequence of Image Processing Technique.

Stages of Image Processing Technique

Image Acquisition From MRI

Images acquired from MRI machine are usually impure and noisy and need to be adjusted during subsequence processes (Nitesh and Geeta, 2017).

Preprocessing

In this stage, the acquired MRI image of the dataset has poor quality and needs the application of an efficient filter before the analysis to improve its visual impact (Shahariar et al., 2019) In pre-processing, the MRI image is converted to the two-dimensional matrix and converting the given MRI image into a greyscale (Damandeep and Surender, 2019) which ranges between 0 and 255 values, where 0 represents the black color and range 255 represents the white color (Shrutika et al., 2017).

The High Pass filter is used to reduce the irrelevant noise from the impure MRI image, and sharps the image when the contrast is between the closing area with little variation in brightness and darkness. The main task of the High Pass Filter is to highlight MRI image of any impurity or noise present is there (Sonu and Saini, 2015).

Image Enhancement

This technique aims to improve the contrast quality of the MRI image and the information of the original data by applying the Histogram Equalization technique which is a computer image processing technique to lower the value area of an image in order to gain a higher contrast by stretching out the intensity range of the image (Shahariar et al., 2019). The application of Anisotropic Filtering is used to enhance the MRI image quality by removing the noise and increasing surface sharpness, without removing significant parts of the image content (Rashid et al., 2018).

Image Segmentation

Image segmentation is the main step of MRI image processing. It is to divide digital image into various segment regions or sets of pixels for easier analysis. It is used mainly to find colors, lines, curves, and boundaries (Chaudhari and Himanshu, 2021).

In this stage, a thresholding algorithm is used to convert a grayscale image into a binary image by replacing each pixel in a grayscale image with a black pixel if the pixel intensity is less than the thresholding value, or a white pixel if the pixel intensity is more than the thresholding value (Sanjay and Sharad, 2018). The following equation of thresholding was applied:

$$g(x, y) = 1, \text{ if } f(x, y) > T \qquad (1)$$

$$g(x, y) = 0, \text{ if } f(x, y) < T$$

The threshold value is T, the original input image is f(x,y), and the position of each pixel in the image is g(x,y). If the current pixel f(x,y) has the value T, then pixel g(x,y) has the value 0. Otherwise, the value 1 is assigned to the pixel g(x,y). When all of the values of "g" are displayed, a segmented image is created. Based on the identification of the MR image's maximum pixel, a segmented image will be obtained (Animesh et al., 2017).

Morphological Operation

It is a non-linear operation related to the morphology of a specific (Chaudhari and Himanshu, 2021). Morphological Operation technique is applied to a segmented image to detect whether the tumor is present or not; if it is present the tumor will appear as a region pixel of high intensity, it is represented by pixels with value one, while the other region of the image is represented by pixel with a value of zero (Umit and Ahmet, 2017).

In this technique, two operations were used

1- Dilation was applied on the binary and grayscale image; it works by object expansion, hole filling, and finally adding all the disjoint objects (Faraz et al., 2019).

2- Erosion was applied to both binary and grayscale images like dilation. Erosion operation erodes the boundary of the object leading to shrinking and the size of the holes which start growing (Faraz et al., 2019).

After the Morphological Operation detects the tumor and a boundary around the tumor region is made, the contour is formed around the tumor. After that, the tumor is extracted from the brain and appears as a clear white spot (Digvijay et al., 2018). Finally, the area and the execution time of each brain tumor studied could be calculated.

Result and Discussion

The MRI image was showed in Figure (2). The application of pre-processing stage of the image processing technique led to the conversion of the MRI image into a two-dimensional matrix, after that the image was converted to grayscale as given in Figure (3b). The MRI image was impure and associated with noise, this problem was decreased through applying a High Pass Filter that sharpened it, see Figure (4). The resulted image was enhanced, by using Histogram Equalization to improve the contrast quality of the image Figure (5). Then, an anisotropic filter was used to remove the noise from the MRI image as shown in Figure (6). Application of the threshold segmentation method to segmented MRI image led to the conversion of the grayscale image into a binary image (black and white) depending on the intensity of the pixel as given in Figure (7). Finally, the morphological operation technique discriminated the MRI images that have a tumor by applying Dilation and Erosion methods of the morphological operation to bound the tumor region through forming a contour around the tumor. The tumor appeared as a clear white spot and distinguished from the MRI image as given in Figure (8),(9). Figure (10) shows the area of the MRI image with the tumor. The MRI image of the brain with no tumor is shown in Figure (11). Our result was supported by (Chaudhari et al., 2021), (Sravanthi1 et al., 2021), (Akanksha and Hemalatha, 2020), and (Faraz,2019) even though different methodologies and algorithms have been applied. Figures (2)-(11) show the processes that have been done in this study. Table (1) illustrates the area of original images of MRI brain tumor by pixel, the area of the extracted tumor, and area ratio.

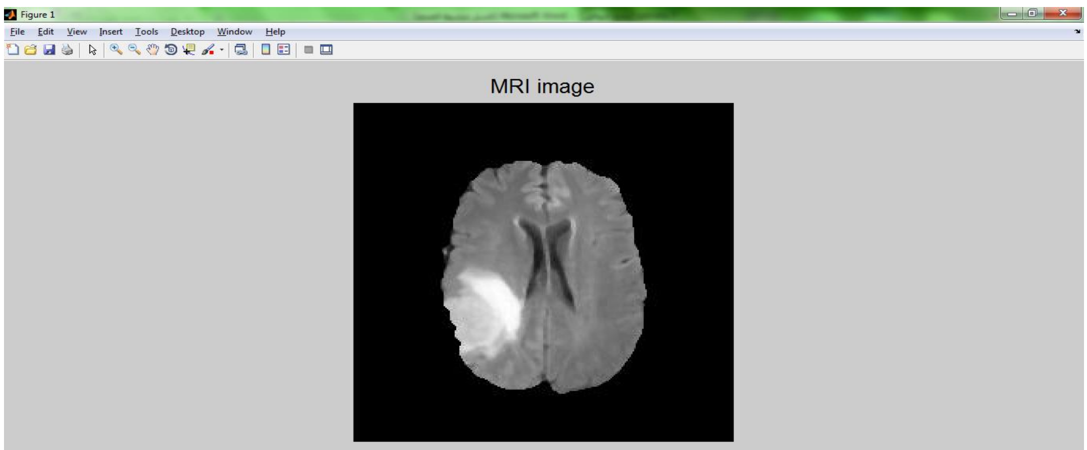


Figure (2): Input Image from MRI.

Figure (3): (a) The Preprocessing of MRI Image. (b) The Grayscale of MRI Image.

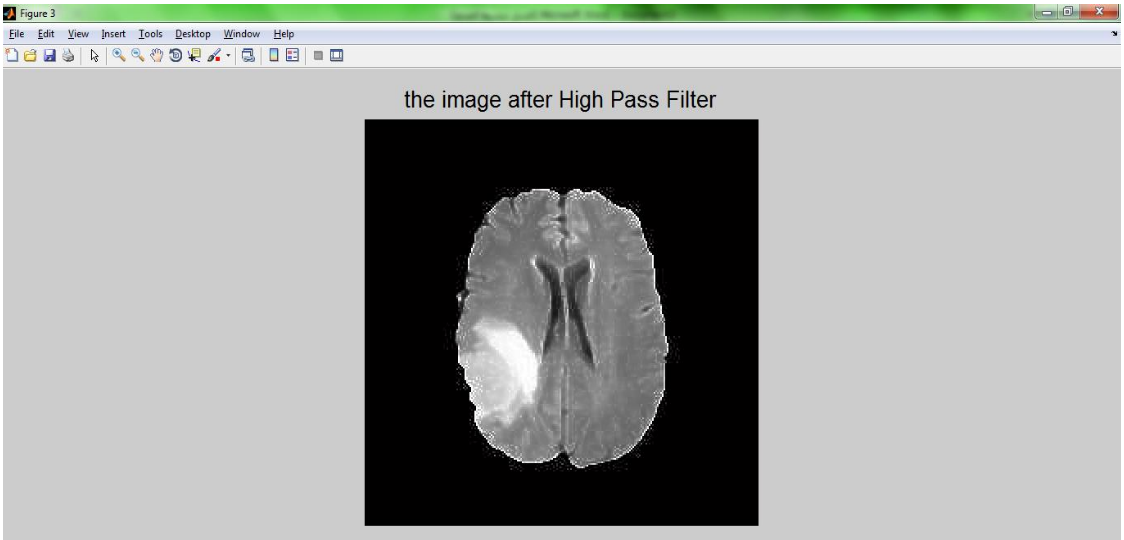


Figure (4): High Pass Filter Applied to the MRI Image.

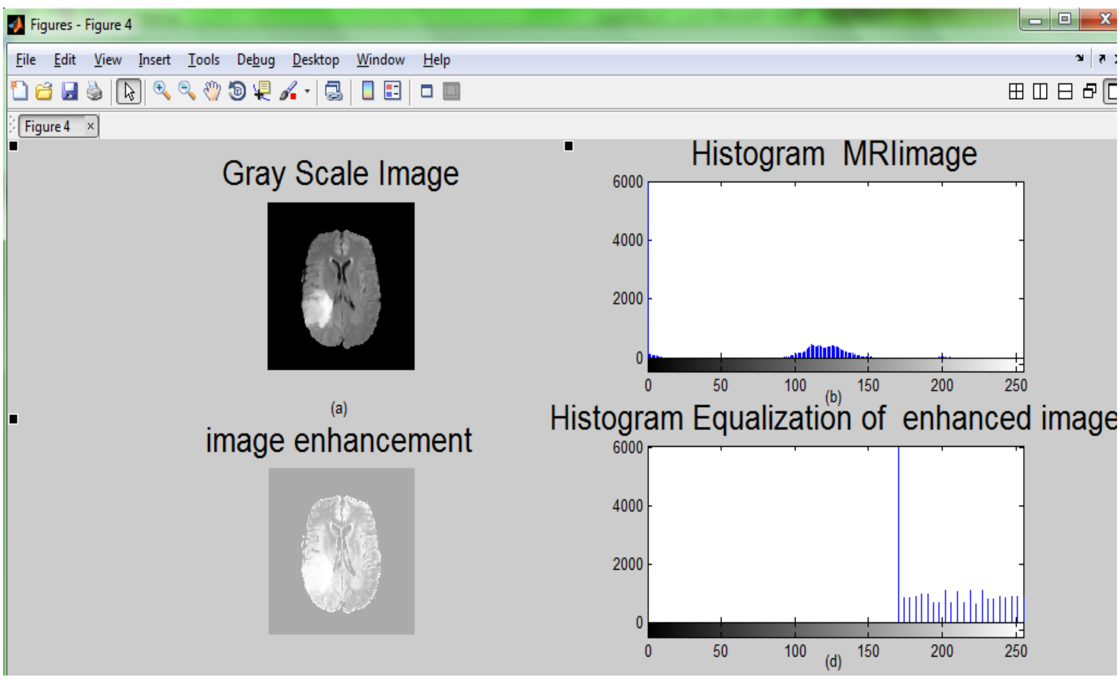


Figure (5): (a) Grayscale Image (b) Histogram of the Grayscale Image. (c) Image Enhancement (d) Histogram Equalization of Image Enhancement.

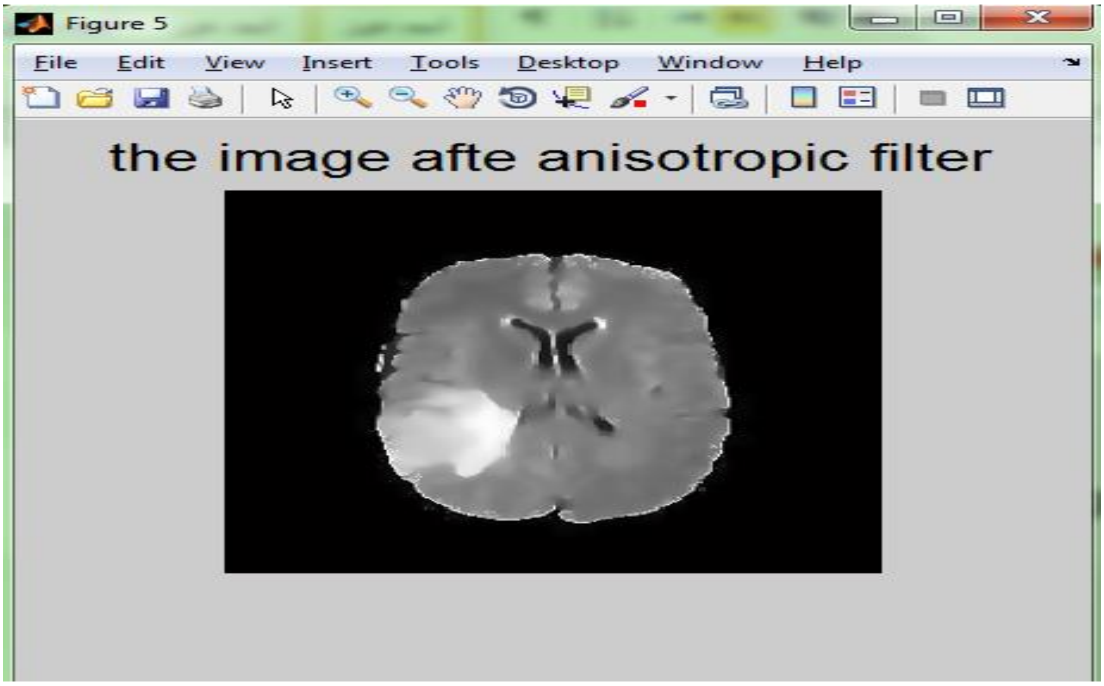


Figure (6): Enhancement MRI Image by Appling Anisotropic Filter.

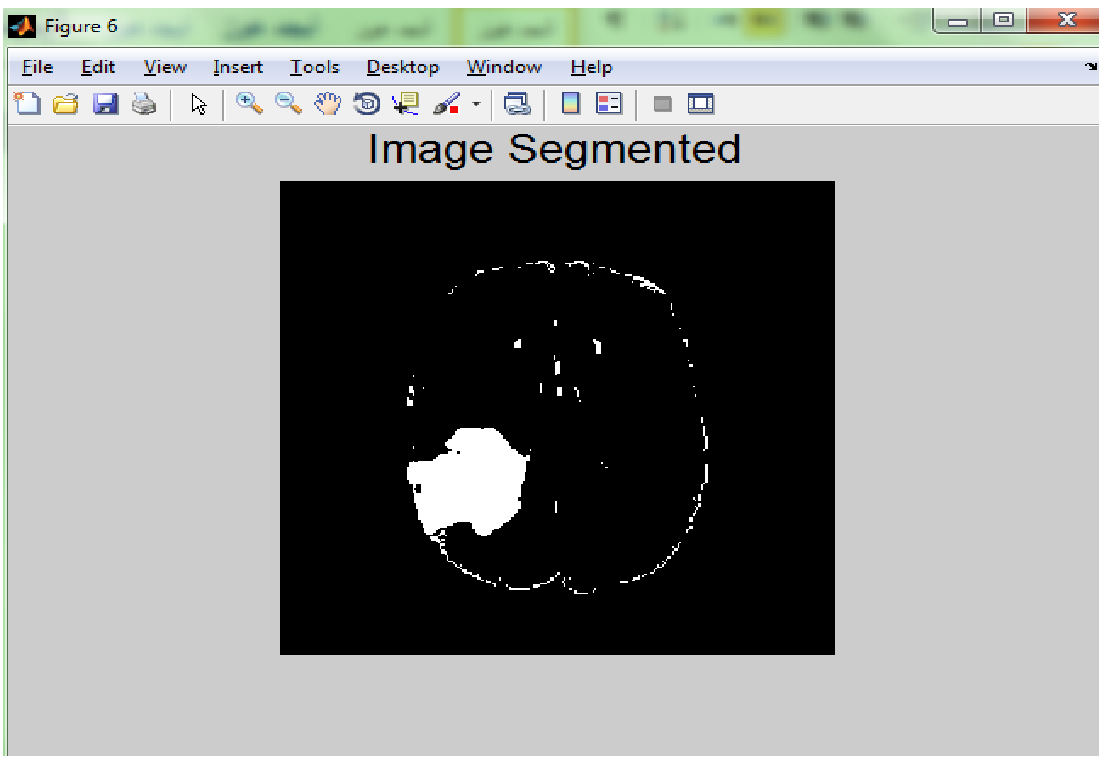


Figure (7): Image Segmentation using Thresholding Algorithm.

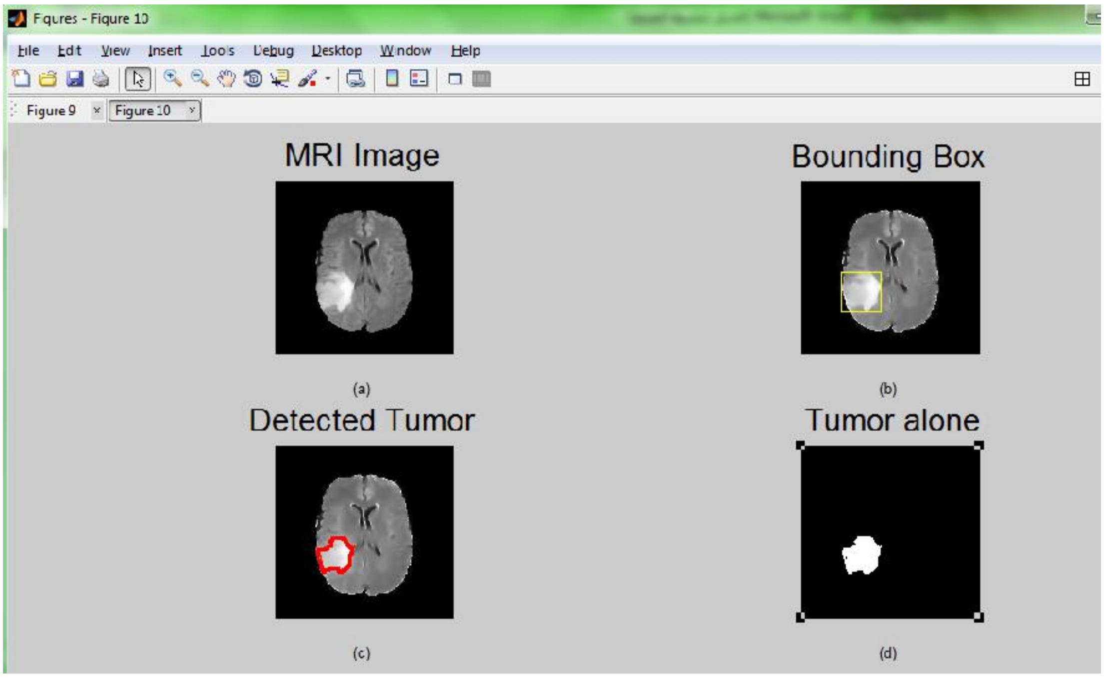


Figure (8): The Result of the Morphological Operation of Brain Tumor from MRI Image. (a) Original image. (b) Bounding Tumor (c) Detect Region in Tumor (d) Tumor Alone.

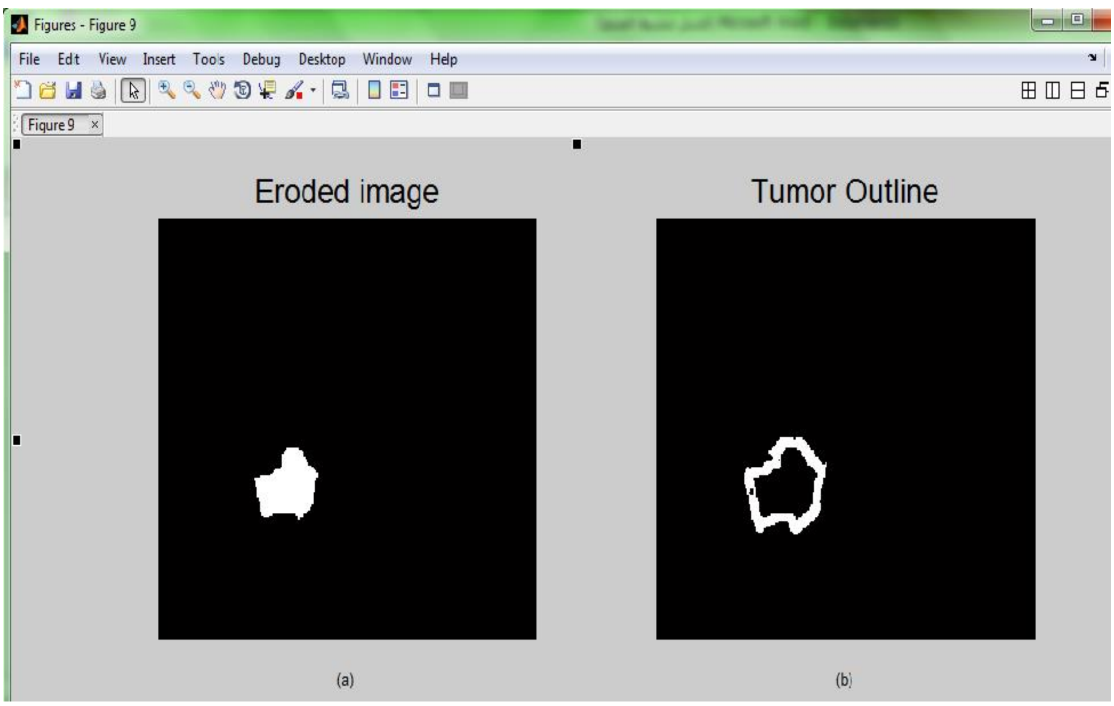


Figure (9):(a) Eroded Image. (b) Tumor Outline Contour.

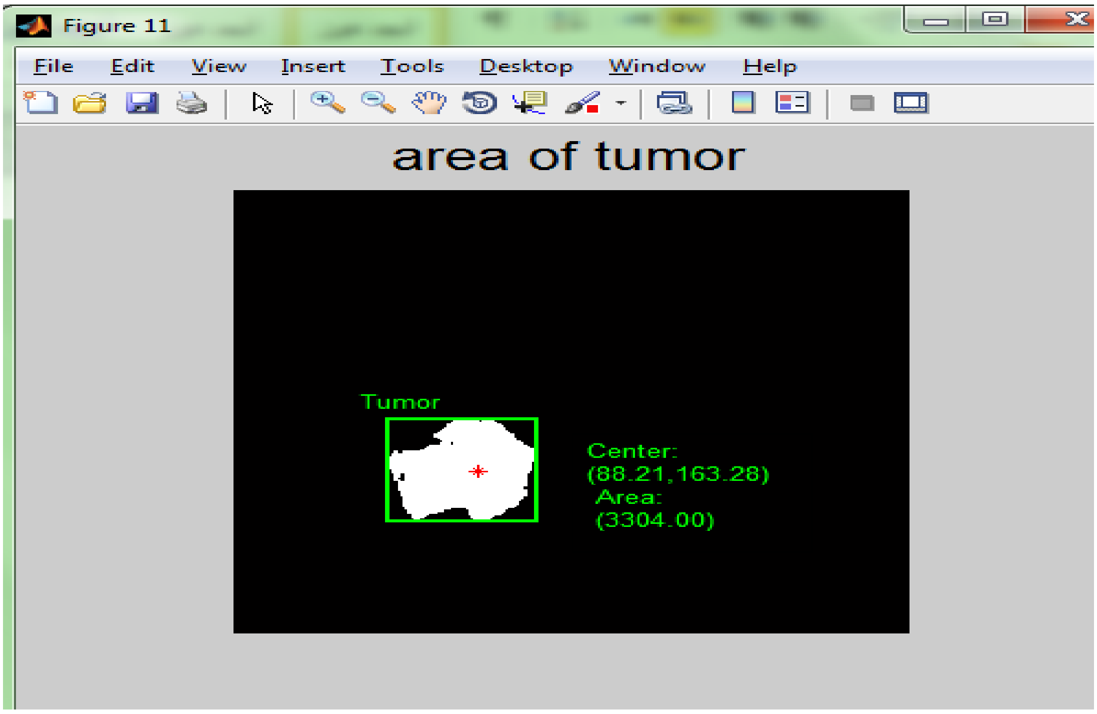


Figure (10): The Area of Tumor.

Table (1): Area of the extracted tumor

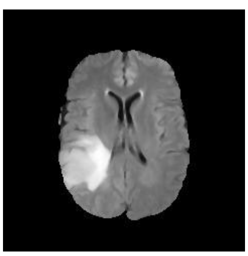
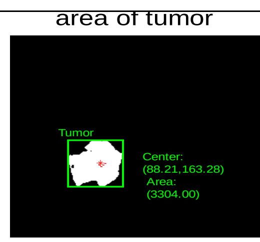
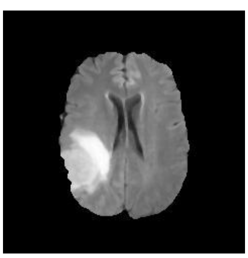
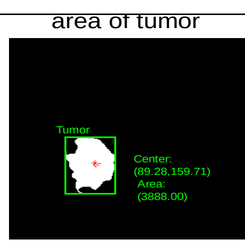
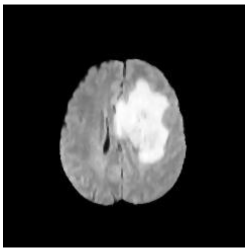
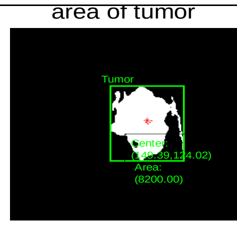
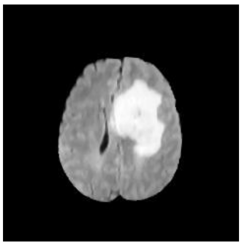
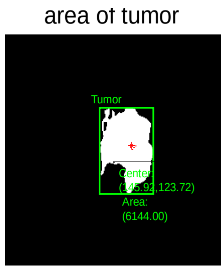
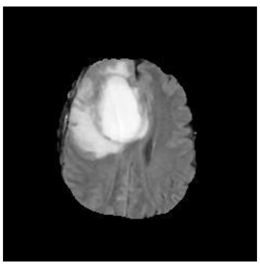
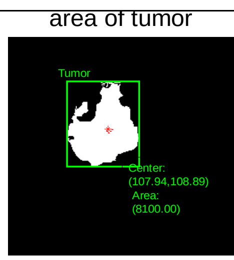
NO. image	Brain tumor of MRI images	area of extracted tumor	Original image size	Area in pixel	Area of extracted tumor	Ratio
Image 1			240*240	57600	3304	0.0579
Image 2			240*240	57600	3888	0.0675

Image 3			240*240	57600	8200	0.1423
Image 4			240*240	57600	6144	0.1066
Image 5			240*240	57600	8100	0.1406

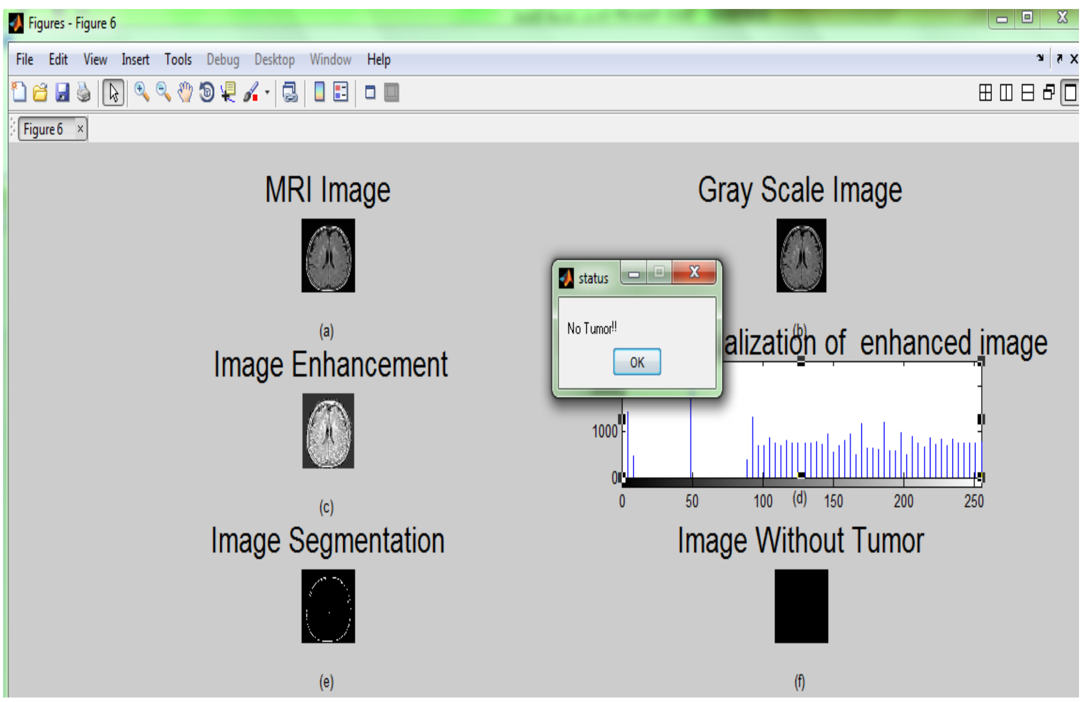


Figure (11): (a) MRI Image (b) Grayscale Image.(c) Image Enhancement (d) Histogram Equalization of Image Enhancement (e) Image Segmentation. (f) MRI Image with no Tumor.

Conclusion

The application of the image processing technique for detecting and extracting human brain tumor during medical diagnosis is of utmost importance to medical analysis. A tumor can easily be detected and extracted from MRI image of human brain by using this technique. Furthermore, this technique improves the accuracy of tumor image and reduces the execution time of the processes. To confirm this process, further work needs to be conducted to study three-dimensional tumor image and use the appropriate algorithms to detect and identify the type of tumor at an early stage.

Reference

- Akanksha, H. and Hemalatha, J. (2020). Detection of Brain Tumor from MRI Images Using MATLAB. *International Research Journal of Engineering and Technology. Vol.07, pp; 772-776.*

- Alexander, Z., Konstantin, S., Mikhail, K. Yousif, H. and Svetlana, K. (2018). Edge detection in MRI brain tumor images based on fuzzy C-means clustering. *International Conference on Knowledge-Based and Intelligent.*

- Amit, D., Mudukshiwale, Y M. Patil (2019). Brain Tumor Detection Using Digital Image Processing. *International Research Journal of Engineering and Technology.Vol.06, pp; 7222-7276.*

- Animesh, H., Ankit, D., Sujit, K., and Abid, A. (2017). Brain Tumor Detection Based on Segmentation using MATLAB. *International Conference on Energy, Communication, Data Analytics, and Soft Computing. pp; 425-430.*

- Anurag, G., and Manish, D. (2020). An Analysis of Image Segmentation Methods for Brain Tumor Detection on MRI Images. *IEEE International Conference on Communication Systems and Network Technologies. pp; 318-322.*

- Chaudhari, D. R, Himanshu, A. P., Tejas, V. B. (2021). Detection of tumor from MRI scan images of the brain using image processing techniques by. *International Research Journal of Engineering and Technology. Vol. 08, pp;3013-3016.*

- Damandeep, K., and Surender, S. (2019). Detection of Brain Tumor using Image Processing Techniques. *International Journal of Engineering and Advanced Technology (IJEAT). Vol.08, pp;501-504.*

- Debnath, B., and Tai, H. (2011). Brain Tumor Detection Using MRI Image Analysis. *International Conference on Ubiquitous Computing and Multimedia Application. pp; 307-314.*

- Digvijay, R., Dheeraj, K., Bhavana, V. and Krishnappa H. K. (2018). Brain Tumor Detection using Image Segmentation Techniques. *International Conference on Communication and Signal Processing. pp; 18-22.*

- Faraz, H., Manish ,K,. and Mawatwal, A. G. (2019). Brain Tumor Detection using Image Processing and MATLAB Application. *International research journal of Engineering and Technology. Vol. 06, pp;372-377.*

- Nitesh K., and Geeta, S. (2017). Automatic Detection of Brain Tumor Using K-Means Clustering. *International Journal for Research in Science& Engineering and Technology (IJRASET). Vol 05, pp;114-121.*

- Rashid, A., Mamun, A. H., and Palash, U. (2018). Brain Tumor Detection Using Anisotropic Filtering, SVM Classifier, and Morphological Operation from MR Images. *International Conference on Computer, Communication, Chemical, Materials and Electronic Engineering.*

- Sanjay, M., and Sharad, W. (2018). Automated Segmentation and Detection of brain tumor from MRI. *pp;2120-2126.*

- Shahariar, A., Mahbubur, R., Mohammad, A. H., Khairul, I., Kazi, M. A., Khandaker, T. A., Bikash C.S., and Sipon, M. (2019). Automatic Human Brain Tumor Detection in MRI Image Using Template-Based K Means and Improved Fuzzy C Means Clustering Algorithm. Big Data and Cognitive Computer. *pp; 1-18.*

- Shrutika, S., Akshata, R., and Swati, K. (2017). Implementation of Image Processing for Detection of Brain Tumors. *International Conference on Intelligent Computing and Control Systems ICICCS. pp; 278-283.*

- Sidra, A., Shahzad, N., Sarwar, W., Syed, M.,and Ussama, Z. (2019). Image Analysis for MRI Based Brain Tumor Detection.

- Sonu, S., and Saini, L. M. (2015). Automatic Detection of Brain Tumor by Image Processing MATLAB. *International Journal of Advances in Science Engineering and Technology. Vol 03, pp;114-117.*

- Sravanthi, N., Nagari, S., Poreddy, R., Siliveru, R., and Suwarna, G., N. (2021). Brain Tumor Detection using Image Processing. *International Journal of Scientific Research in Computer Science, Engineering and Information Technology. Vol. 07, pp; 348-352.*

- Umit, I. and Ahmet, I. (2017). Brain tumor segmentation based on a new threshold approach. *International Conference on Theory and Application of Soft Computing, Computing with Words and Perception. pp;580–587.*