BRAIN TUMOR DETECTION FROM MRI IMAGE USING MATLAB

This Thesis submitted in partial fulfillment of the requirements for the Award of Degree of
Bachelor of Science in Electrical and Electronic Engineering

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January 2020

Certification

This is to certify that this thesis entitled "**Brain Tumor Detection from MRI Image Using MATLAB**" is done by the following student under our direct supervision and this work has been carried out by him in the laboratories of the Department of Electrical and Electronic Engineering under the Faculty of Engineering of Daffodil International University in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering.

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Dedicated to

My Parents

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LIST OF ABBREVIATIONS

MRI	Magnetic Resonance Imaging
MATLAB	Matrix Laboratory
CNS	Central Nervous System
CAD	Computer Aided Detection
CT	Computed Tomography
PET	Position Emission Tomography
GUI	Graphical User Interface
2-D	2 Dimension
ADC	Analog to Digital Converter
DAC	Digital to Analog Converter
ANN	Artificial Neural Network
HNN	Hopfield Neural Network
MLP	Back-propagation learning algorithm
SOM	Self-Organizing Maps
HSOM	Hierarchical Self-organizing Map
FCM	Fuzzy C-Means
ANFIS	Adaptive Network Based Fuzzy Interface System
KNN	Knearest Neighbors
SVM	Support Vector Machine
CAS	Computer-Aided Diagnosis System
RGB	Red, Green, Blue

ACKNOWLEDGEMENT

First of all, I give thanks to Allah. Then I would like to take this opportunity to express my appreciation and gratitude to my thesis supervisor **Mr. Saikat Basak, Senior Lecturer** of the **Department of EEE** for being dedicated to supporting, motivating and guiding me through this thesis. This thesis can't be done without his useful advice and helps. Also thank you very much for giving me the opportunity to choose this thesis.

Apart from that, I would like to thank my entire friends for sharing knowledge; information and helping me in making this thesis a success. Also thanks for lending me some tools and equipment.

To my beloved family, I want to give them my deepest love and gratitude for being very supportive and also for their inspiration and encouragement during my studies at this University.

ABSTRACT

One of the most dangerous diesis for the human is a brain tumor, it needs to detect early otherwise nothing remain to do by a doctor or nature. The present situation of detecting tumor depends on the neuro-specialists and radiologists; it is simple that a man or woman can make mistakes or human error can occur. Though the accuracy of manual detection is not bad but this process is time-consuming. Magnetic Resonance Imaging (MRI) is the main source for diagnosing the brain tumor. This study describes the way how to find and mark a tumor from an MRI image with high accuracy.

In this proposed system the process is too much faster than the manual system, and it doesn't waste a second if the MRI image has no tumor on it. It can detect if there any tumor exists or not within a few milliseconds and after performing a few analyses if a tumor detected then goes for the farther procedure which is time-saving. This thesis also performs the Computer-Aided Detection System (CAD System) which makes it easy to analyze for radiologists and doctors, like how big the tumor, exactly where the tumor is and the shape of the tumor, etc.

This thesis is performed by three-stage; the first stage is image pre-processing and post-processing to enhancement the quality of the MRI image. It makes the image more suitable for farther analysis. With a certain threshold label, main image is converted to a binary image. A statistical property is applied in the second stage to measure all properties of the image region. It extracts the solidity and high-density area from the tumor and performs few operations. In the third stage, the tumor is detected by a few logical operations and make it more visible and mark exactly where the tumor is. The performance was successfully tested and achieved the best result with an accuracy of almost 96%.

CHAPTER 1

INTRODUCTION

1.1 Introduction

The abnormal mass of cells results in tumor either in the brain or another portion of the body. Any tumors are dangerous. Proper diagnosis and early detection can prevent the patient from a big danger. The tumor inside the brain is known as brain tumor and some tumors are called brain cancer. The children, middle age and also old age peoples can be affected by a brain tumor. Many kinds of brain tumors available but basically, it is two types, primary and secondary. And in the huge concept, the tumor is divided also into two types those are Benign tumor and Malignant tumor. Different tumors are explained in later sections.
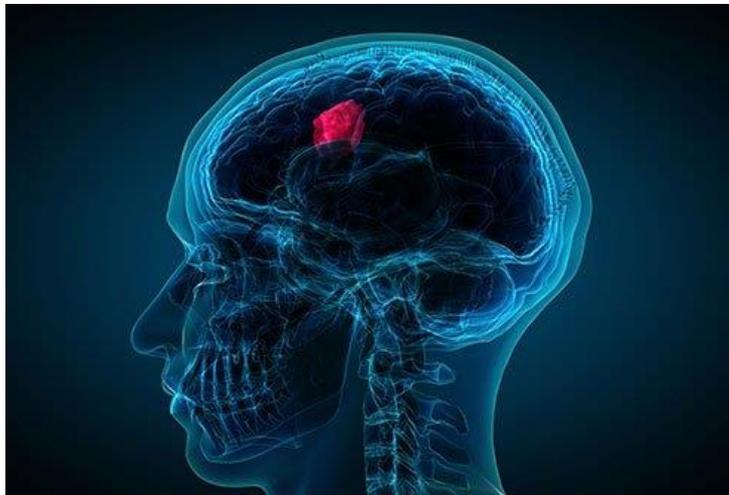
Figure 1.1: Illustration of a Brian Tumor [4]

1.2 Statistics

According to cancer.net more than 23,820 adults (13,410 men and 10,410 woman) will be diagnosed from the United States because of the primary cancerous tumor of the

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brain or spinal cord. Almost 85% to 90% of all brain tumor is primary CNS (Central Nervous System) tumor. Under the age of 15, about 3,720 children will take diagnose for CNS tumors this year.

Almost the 10th leading cause of death is the brain or other nervous system cancer. Almost 17,760 adults (9,910 men and 7,850 woman) primary cancerous brain and CNS tumors in this year. A 5-year survival survey is done, the result is almost 34% men and 36% woman can survive when cancer or CNS tumor is detected [1].

1.3 Problem Statement and Significance

The brain tumor is most dangerous diseases in the present world. Timely detection is most important for a beautiful life. Present imaging technologies such as Magnetic Resonance Image (MRI), Computed Tomography (CT), Positron Emission Tomography (PET), etc. are used to capture the brain image. MRI gives a more accurate visualization of the anatomy of the brain than the CT and PET. CT and PET have also side effects too. The process of brain tumor detection is done manually by an expert. There are some difficulties such as it takes a huge time to find the tumor from a complex MR image and it requires a group of people to take a final decision, also the quality of image, contrast, brightness may vary and those parameters can help to take the wrong decision. To avoid those problems, the automated detection system of brain tumor becomes important. In the medical system, there are no suitable methods to detect the brain tumor. The different research on medical technology is working to detect brain tumors with high accuracy [8]. This was a challenge for me to design a system that can detect a tumor with some information.

1.4 Objective

The main objective is to develop a computerized system to detect brain tumors, lesions, abnormalities. Specifically, the objectives are:

i.   To investigate the tumor and exactly what the tumor is.

ii.   To study about the tumors nature and types of tumors. And how they develop in the brain.

iii.   To apply the knowledge of MATLAB for finding tumor.

iv.   To design a Computer Aided Detection (CAD) system for detecting tumor from MRI image.

1.5 Scopes

Brain tumor detection will be faster by using this thesis work. It can detect tumors precisely and can decide whether the MRI image has a tumor or not. This can save the valuable time of many experts. This thesis can help physicians to find the brain tumor fast and accurately from an MRI image. The detection is not only detecting the affected part of the brain; it is a Computer-Aided Detection System (CAD System) which means it gives more information that can help doctors to make farther decisions. It also gives an idea about the shape, size, exact location, boundary and position of the tumor. That makes this approach different from others. I want to more improve it by interfacing into one frame which can visualize it as a professional brain tumor detector, that can be a Graphical User Interface (GUI) or other application.

1.6 Method

In this study MATLAB image processing operation was used as the diagnosis method for detecting tumors from Magnetic Resonance Image (MRI). The detection system is operated into two stages, the first stage is preprocessing and enhancement and the second stage is segmentation and classification. The main image is converted into a 2-D binary image after threshold the image. Extracted all parameters from the image to find the solidity and area of the content remaining into the image. Then apply a condition to find the tumor and the tumor turned into more visible by applying one of the Morphological operations called dilation. Dilation increases the brightness and reduces small dark pixels from the tumor zone. Finally, the tumor is plotted to a graphical interface to view the audience. The main attraction is it can detect that the MR image contains any tumor or not and gives a message that 'No tumor' or 'Tumor is detected'.

1.7 Thesis Outline

Chapter 1 Introduces the Introduction of this study and explained briefly the methodology of the study.

Chapter 2 shows a study of the literature review of related works which was used to improve the brain tumor detection and segmentation procedure.

Chapter 3 describes the theoretical model of the study.

Chapter 4 describes methodology in detailed.

Chapter 5 reviews the all results found step by step through the study and provides a discussion on it.

Chapter 6 specified the limitations of the study, provides the future works that may be approached and conclusion.

1.8 Summary

First of all, I discuss tumors, types of tumors and the grade of tumors. I also discuss the advantages of the automatic tumor detection process. Then I discuss the problem statement, methodology, and objective of this project. At last, I discuss the project outline in this chapter.

CHAPTER 2

LITERATURE REVIEWS

2.1 Introduction

In the last century, many researchers have tried to detect and classify brain tumors by applying different methods from a digital image. Also, several image processing tools and various machine learning tools are developed to work with. In this chapter, this kind of study will be discussed.

2.2 Digital Image Processing

The digital image processing is a computer-based algorithmic process to carry out image processing on the digital image. Digital image processing is the subcategory of digital signal processing. It has many advantages as compared to analog image processing. If a digital image processing is a system, they must have some hardware (equipment) and software (computer program), which can get an image, detect the object using suitable sensors, analog to digital converter (ADC), storage for image, process the image and finally the display output for the image, normally the display is a computer monitor or a television, the display requires an analog video signal by a digital to analog converter (DAC). The digital image processing form by different methods like feature extraction and segmentation, section 2.3 contains details about segmentation and extractions.

2.3 Image Segmentation and Detection of Tumor

It is very time-consuming to segment or detects brain tumors manually from MRI of a large dataset for that reason the automated detection and segmentation system helps to overcome the time taking process. The automated system has problems to achieve this

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goal. For instance, the major problem is pixel intensity infringes the independent and identically distributed assumptions of an image due to the very nature of the brain MR image, Presence of a considerable amount of artifacts and intensity inhomogeneity in MR image [16,17].

Different methods are introduced in recent years, for automation to identify the brain tumors, scanning, and imaging. These methods can be classified into two:

- Intelligent based

- Non-Intelligent based

The intelligent based method contains artificial neural networks, support vector machine, fuzzy logic, and hybrid process. Whereas, the non-intelligent method contains thresholding and region growing. However, there is no clear partition between the two methods. Even, an intelligent based method is used as non-intelligent. But it is tempered to expurgate the output. In the following few notable methods have been reviewed.

2.3.1. Thresholding based methods

In thresholding approach; image is segmented based on gray level intensity value of pixels. A thresholding procedure attempts to fix an intensity value, called the threshold, which separates the desired classes. The segmentation is then achieved by forming all pixels with intensity greater than the threshold level into one class, and all other pixels lower than the threshold level into another class.

However, for the many segmentation process thresholding is used like initial step. Only two classes are generating and it is the main limitations of thresholding also when confronted with structure that lace clear border that means then it does not work properly [18]. Thresholding image segmentation is considered as a powerful and simple process to segment image which have light object on dark background [19]. Thresholding is the technique of image space region, which is, characteristics of image [20]. By applying threshold, it converts a multilevel image to a binary image.

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For instance, it selects a perfect thresh hold in order to divide image pixels into many regions and flow tide the objects form the background. Any pixel (x, y) is accounted as part of the object, provided that its intensity is equal or greater than to the threshold value [21, 22].

Thresholding value are two types, such as global and local thresholding [23]. When we want to divide an image into object and background, we put a fixed single threshold value and this is called global threshold. On the other hand, if we have several objects along with the background, we have to define multiple threshold and this threshold are called local threshold.

In recent research, Tumor detection and segmentation method based on integrated thresholding [24, 25] by using watershed and histogram analysis have been proposed. But this papers didn't mention the data used for testing and affirm their methods. Similarly, no quantitate analysis or result has been provided.

2.3.2. Region growing based method

Region growing is the technique for the extraction of a region according to a predefined criterion. This process requires a start point which is manually selected by an operator and extract all pixels related to initial seed value with the same amount of intensity. Region growing is so sensitive to noise. Overlapping the gray values in MR Image can bring a different region to be connected.

Region growing is always used with another method because it is not sufficient to segment the brain accurately and strongly. Pohle and Toennies refer to that region growing can be a mobilized technique using multi multilevel sets of boundary information [26]. In the algorithm of pohels research, region growing is used as a propagation force and boundary information is used as a stopping standard. Pohel and Toennies successfully applied this technique on 246 images containing axial tumors attained from 10 patients [26]. This method depends on manual input so we can say this method is semi-automatic, which means that is not fully automatic. To make this

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method automatic it required to make an autonomous input. Region-based segmentation method is two types:

    i.   Region growing

    ii.   Region splitting and merging

2.3.2.a Region Growing

It is a method which denotes, that set pixels in an entire image together as a group into a large region or sub-region depending on the pre denoted criterion [27]. Region growing method has four steps:

- ❖ Setting a group of seed pixels in an original image [28].
- ❖ To choose a set of unique standard for instance color or gray label intensity and reveal a stopping rule.
- ❖ To grow region by attaching each seed of neighboring pixels which have pre denoted characteristics similar to seed pixels.
- ❖ To manage the growing region when it feels that no more pixels suit the standard to be included to the territory.

In Figure 2.1, the dot of four arrows denotes seed point and arrow means the growing directions. That means the showing directed area will be grown from seed point. In Figure 2.2, Region is grown in neighboring pixels from the seed pixel by adding and finally the size of the region increased [29].
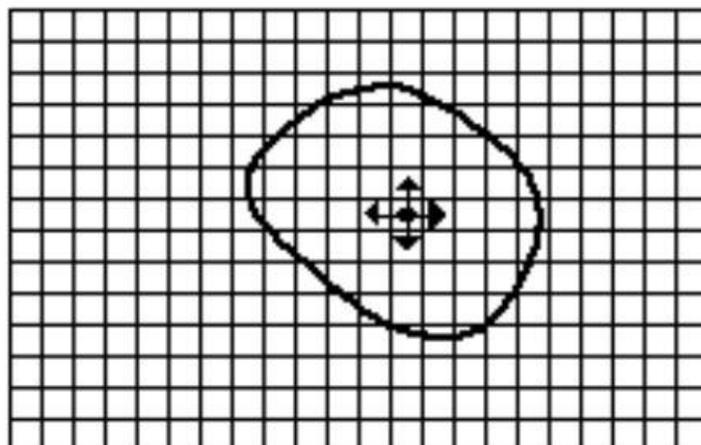
Figure 2.1: Start of growing region [29].

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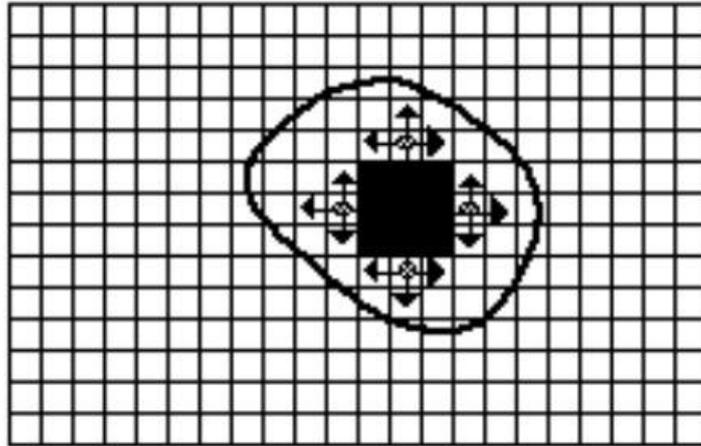
Figure 2.2: Growing process after a few iterations [29].

2.3.2.b Region Splitting and Merging

The fundamental idea of region splitting is to divide an image into a set of disconnect regions that are compatible within themselves. In the place of selecting a seed point, the user may break the image into a set of different region and merge the regions to satisfy the segmentation process [20, 30]. The method is described here:

- ❖ Firstly, take the whole image as an area of interest.
- ❖ Look at the area of interest and settle upon if all pixels of the region gratify some similarity discipline.
- ❖ If it is true, then the area of interest agrees to a part in the image.
- ❖ On the other hand, it false then the area of interest to be divided (Normally into four equal sub-regions) and imagine each of the sub-region as an area of interest.
- ❖ This procedure will continue until the next divide happen; basically for the worst case this occur when the size of the areas is just one pixel.
- ❖ This is called divide and conquer or top down method.

Besides that, a merging method is used after every divide which compares nearby areas and merges them if essential. This algorithm is called the Split and Merge algorithm [31].

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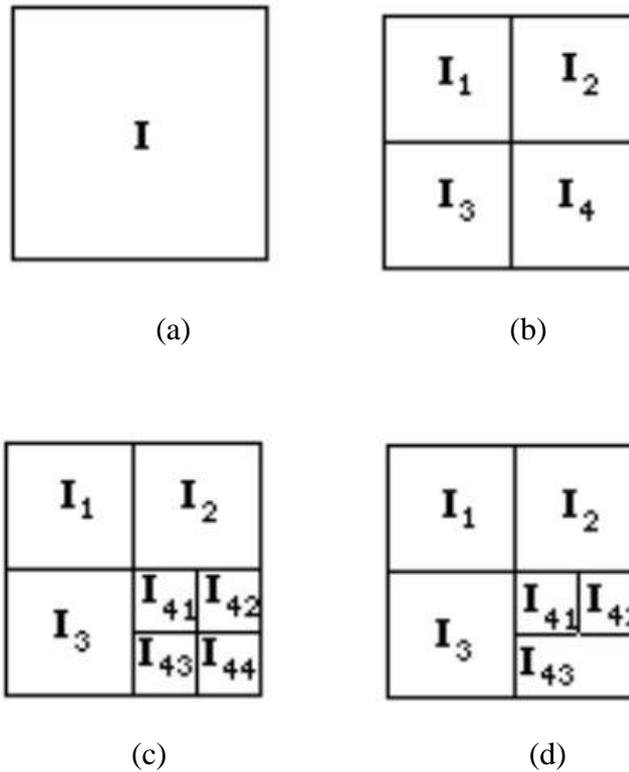
(a) Whole Image, (b) First Split, (c) Second Split, (d) Merge

Figure 2.3: Example of Region Splitting and Merging [31]

In figure 2.3(a) 'I' is the total image, All the pixels are not similar so it divided like figure 2.3(b) Imagine that all the pixels of the region I1, I2 and I3 are similar but only I4 is different. For that reason, I4 is farther divided into a picture of 2.3 (c). Let the all pixels are similar concerning that region, by comparing the divided regions of I4, the regions I43 and I44 are found to be similar. For that reason, these two are merged in Figure 2.3(d) [31].

According to Figure 2.4, we can narrate the dividing of that image "I" by using a tree formation, using a quad tree. Each node has almost four generations except for one which is merged [31].

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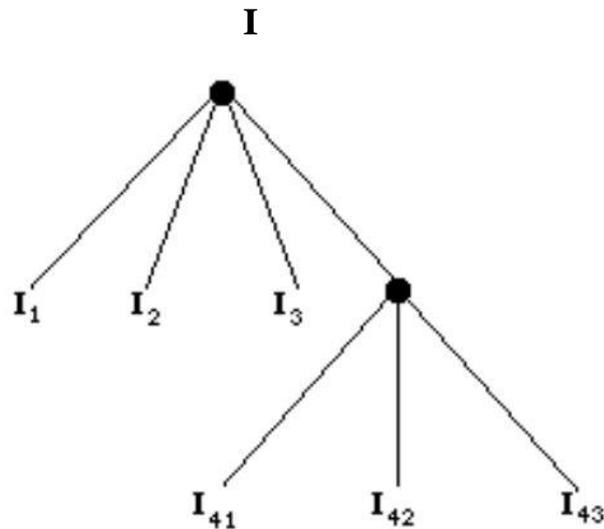
Figure 2.4: Region Splitting and Merging Tree [31].

2.3.3. Neural Network Based Method

The artificial neural network (ANN) computational model is used in a neural network-based segmentation method. The artificial neural network computational models form the processing components (called neurons) and weighted connection between them. The connections have individual multipliers. In that case, the weight coefficient acts as a multiplier. The value to coefficient can't acquire by assigning or default, it needs the training to achieve the value of the coefficient. There are different types of neural networks developed by engineers and all of those are using based on field requirements. Many of them are using to segment the medical image. The modular neural network, Multilayer perceptron, Hopfield neural networks (HNN), Back-propagation learning algorithm (MLP) and Self-organizing maps (SOM) neural network are used in the segmentation process. Because of their ability to learn the segmentation process, many researchers are attracted to it for image segmentation operation.

The application of MLP is the segmentation of the brain tumor and which is used by [32], who primarily trained the neural networks by using a diagnostic known Image. The MLP model was developed from the information acquired by the training process. This information was used to build the training datasets. Which was then applied to segment the next sample. The whole dataset of image iteratively segmented.

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T. Logeswari and M. Karnan used SOM to detect and visualize which they called hierarchical self-organizing map (HSOM) [33]. Detection and visualization can be done by self-organizing map (SOM), SOM is an extraordinary type of unsupervised artificial neural network. In their study, the SOM is a special type of modified by them. Their total system works in two stages, in the first stage, the brain image from MRI is preprocessed to omit the different effects. And in the second stage, they applied HSOM to segment the image.

Mehmed Ozkan, Benoit M. Dawant; they proposed a study of investigation on artificial neural networks using MRI image, X-ray and CT image of the brain. They set the learning parameters first of all. Secondly, the comparison occurred with these learning parameters, and then a small training section is exerting. And then the generalization section is bringing to bear upon to develop the adaptive learning scheme. Finally, the result of segmentation comes out from both the artificial neural network and the maximum likelihood classifier and they are compared to contour painted manually [43].

2.3.4. Fuzzy based method

The fuzzy-based method is basically a set of mathematical principles for wisdom agency founded on a degree of membership instead of classical binary logic. The segmentation using the Fuzzy system grant for the development of the algorithm to execute the task related to human behavior intelligence. Dunn indicates image segmentation by using the fuzzy c-means (FCM) clustering algorithm [34]. Different researches have invented FCM and its improved version for brain tumor segmentation from MRI brain image.

Gordillo applied the fuzzy method to detect and segment tumors using various features like expert knowledge executed from the MR image to build fuzzy rules. This is totally an automatic system and indicates unsupervised learning. Knowledge extraction was performed using histogram analysis to adjust the MRI data [35]. The segmentation and detection result is good and the highest and lowest score is 93% and 71% respectively.

The experiment is done only two types of brain tumors those are glioblastoma and meningioma.

2.3.5. Hybrid Based Technique

The hybrid system is generated from mixing the different methods of machine learning algorithms. To find a better solution this method is created as compared to using a single method to solving problems.

Noor eliaza studied adaptive network-based fuzzy interface system (ANFIS), fuzzy c-means (FCM), Knearest neighbors (KNN) for segmentation of brain tumor [36].

Fuzzy Kohonen neural network is implemented by Nahla Ibrahim for brain tumor detection and segmentation from the MR image [37]. He used parameters like standard deviation, area, and entropy to segment tumor from MR image but he did not use any parameter of preprocessing for removing noise. As a result, Nahla Ibrahim got a lack of accuracy in qualitative and quantitative analyses.

2.3.6. Other Brain Tumor Detection and Segmentation Technique

Phooi Yee Lau developed a tumor detection method depending on three parameters, the parameters are gray (G), contrast (H) and edge (E) values. This method studies the EGH parameter in a supervised block of input images. This blocks compared with standard parameters to find abnormal occurrence usually lesion or tumors in the brain. The experiment is performed in different MR image dataset. Phooi described that the experiment result is effective to apply for the detection of tumors. But, these papers did not specify the data used for testing and validating their methods. Similarly, no quantitative result has been provided [38].

Pooja Dang shows how to detect a tumor from the MR image after performing a few operations. First of all, they applied some noise removal operations such as histogram, image division, etc. and then perform few segmentation operations, for instance, Computer Threshold Segmentation, Computer Watershed Segmentation, etc. and finally they applied morphological operation to extract the tumor region from the MR

image [39]. They told that this method is efficient but they don't show the resource of data and also the numerical result or accuracy.

Esmail Hassan develops a MATLAB GUI (Graphical User Interface) method to segment MRI for finding a brain tumor. They start with filtering which is Prewitt horizontal edge-emphasizing filter. And next, they do the operation which is watershed pixels and finally, they did the GUI designing. After a huge explanation about GUI they don't put any information about the data and also they did not mention any numerical results like accuracy, fault, etc. They just did the GUI process accurately even the GUI interface never show the extracted tumor alone [40].

Pranjal Jain develops a flow chart as a method, which is applicable to extract a brain tumor from the MR image. They apply a few operations to find that. Firstly, the preprocessing is done and then segmentation, morphological operation, watershed segmentation to be done. And finally, the calculation of tumor area and tumor location is done by this flow chart. After all this operation the whole system setup is included in a GUI to make a better working experience. And they show their prototype works fluently but these papers didn't mention the data used for testing and affirm their methods. Similarly, no quantitative result has been provided [41].

J. Zhou used a one support vector machine (SVM) to perform brain tumor segmentation. This method has the advantage of working to the high dimensional feature spaces [42]. The segmentation is acquired by region based explanations. The system achieved a satisfactory result, but this method is needed continuous user communication for the labeled samples.

2.4 Computer-Aided Diagnosis (CAD) System

Firstly, Computer-aided diagnosis (CAD) is a system by which doctors and physicians can get help from it. It can assist doctors in terms of the analysis of medical images. An image of X-ray, Ultrasound, and MRI contains huge important information. Radiologists had to spend many times to extract that information from this image, but by applying the Computer-Aided Diagnosis System (CAS) radiologists can analyze

and evaluate the image accurately within a very short time. CAD can scan a digital image which is very helpful for analysis. This technology is combining elements of radiological image processing along with digital image processing and artificial intelligence. A common application of this method is tumor detection.

2.5 Summary

The chapter contains the details of different studies. Some of them are reliable some of them are not suitable for the present situation because the technology becomes more advanced. We saw that much research work is already done on the topic of tumor detection and segmentation. The detection method is complex in a neural network-based technique. First of all, the program needs training and then it performs the detection operation most accurately. Besides the complex method, there is some general method that exists, the threshold-based method is one of them. By applying thresholding, few filtering and few more logical operation easily can detect a tumor from an MRI image. And in this study, I have tried to apply for my work on more than hundreds of MRI images.

CHAPTER 3

THEORETICAL MODEL

3.1 Introduction of Brain Tumors

The abnormal mass of cells results in tumors either in the brain or another part of the body. Any tumors are dangerous but the brain tumor is more dangerous for humans because the most sensitive area of the human body is the brain. The brain controls the whole system of the human body, if it is affected by tumor then the whole system can collapse. Tumors can be separated as Primary and secondary.
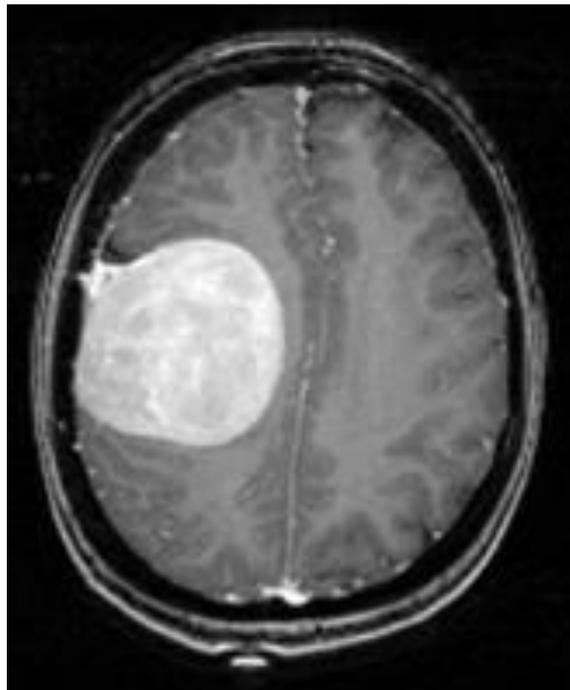
Figure 3.1: Inside of Brian with Tumor

The tumor that originally starts in the brain is called a primary brain tumor, they can be Benign (1.1.1) or Malignant (1.1.2) types. That kind of tumor that starts other parts of the body and spread to the brain is called a secondary brain tumor. The secondary brain

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tumor is cancer and originated most likely breast, kidney, bladder and lung cancers, leukemia, lymphoma and melanoma [3]. Brain tumor types discuss in section 1.2

3.2 Types of Brain Tumor

Brain tumors categorized into two types:

    i.   Benign Brain Tumor

    ii.   Malignant Brain Tumor

3.2.1 Benign Brain Tumor

This type of brain tumor doesn't have cancer cells. They grow slowly and don't show any symptoms to the patient. They can be removed on their own and don't often spread to the tissue around them. They should be life-threatening if they pressurize any part of the brain basically when the tumor grows big inside the brain. Sometimes a Benign Tumor can become Malignant Tumor over time [2]. Moreover, some benign brain tumors can turn into fast growing malignant tumors [9]. This process is known as the transformation of malignant. The most common types of Benign Brain Tumors are:

3.2.1.a Acoustic Neuroma

Also called Vestibular Schwannoma. The acoustic neuroma is a benign tumor of the nerve of balance and hearing. That can cause a problem in our self-balance and hearing system of the human body. If they become large they might be very serious [10]. It is located in the posterior fossa (backside of the skull), in the angle of the cerebellum and pons.

3.2.1.b Meningioma

This is the tumors of the membrane which covers the brain. This types of tumors are slow-growing and about 90% of them is a benign tumor. Meningioma is originated in the central nervous system. They occur more in a woman compared to men [11].

Meningioma is commonly located between the cerebral hemispheres or over, at the base of the skull, and in the back lower part of the brain is known as the posterior fossa [12].

3.2.1.c Craniopharyngiomas

Tumors often occur near the base of the brain. Which is common in children, teenagers and young adults [11]. Craniopharyngioma is an uncommon tumor that usually forms just above the pituitary gland. it can form from different types of brain or spinal cord cells [12].

3.2.1.d Chondroma

It is a benign tumor, not quite known and it tends to evolve at the base of the skull, especially near the pituitary gland area. It is generally slow-growing and might be present for a long time before causing any symptoms. These tumors can grow to a large size and may find as a single or as multiple tumors [12].

3.2.2 Malignant Brain Tumor

This type of brain tumor has cancer cells. The growth of this tumor may vary but the cells of this tumor can attack the healthy cells around it. It grows faster than the Benign Brain Tumor. About 40% of brain and spinal cord tumors are malignant [9]. These includes:

3.2.2.a Oligodendroglioma

Oligodendroglioma is the third most common glioma, about 2-5% of all primary brain tumors and 5-18% of gliomas. They are common at the age of 40-60 years and adult people [13]. These tumors evolve from oligodendrocytes, which is one type of cells that make up the supportive, or glial, a tissue of the brain. Oligodendrogliomas can be low-grade (Tumor grade II) or high-grade (Tumor grade III X).

3.2.2.b Glioblastoma

These types of tumors are common in adults and it is a high-grade primary brain tumor. They can also grow to the children but it is seldom. It is in the group of brain tumors called a glioma. They grow from glial types of brain cells. There are also primary and secondary types of Glioblastoma [14]. The growth rate increase with age, and affect more men than women. For the children only 3% of all brain tumor is Glioblastoma. It can be found in any place of spinal cord and brain but in general, it found in the cerebral hemispheres [12].

3.2.2.c Medulloblastoma

This is a common type of primary brain tumor in children. This is evolving in the bottom part in the brain. This tumor usually arises in the cerebellum. This is a high-grade tumor.
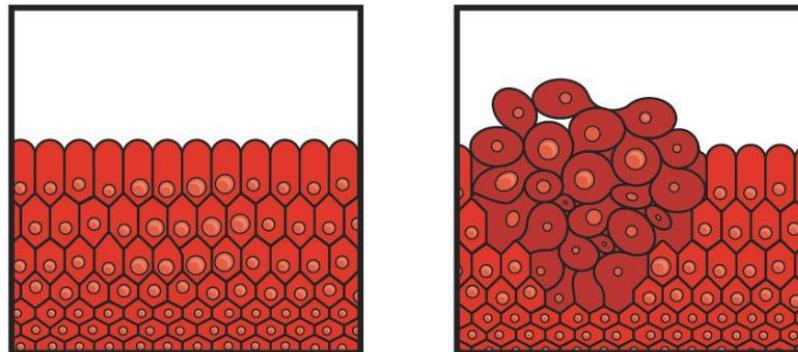
Figure 3.2: Cells forming a tumor. [5]

3.3 Tumor Grade

By depending on the cells look under a microscope, the grades are [15]:

- ❖ Grade I: The tissue is benign. The cells are closed to the normal brain cells and finally, they grow slowly.

- ❖ Grade II: The tissue is malignant and the cells are closed to the normal cells as the Grade I tumors.

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- ❖ Grade III: The malignant tissue contains cells that are not similar to normal cells. The abnormal cells are operatively growing.

- ❖ Grade IV: The malignant tissue contains cells that closed to the abnormal cell and supposed to grow quickly.

3.4 Magnetic Resonance Imaging (MRI)

Magnetic Resonance Imaging (MRI) is used to scan the internal organ or structure of our body by emitting radio waves and also a large magnet is used and a computer. MRI is used for various tasks and day by day the usage is increasing. Basically exceptions of the brain and spinal cord, tumor and other exceptions of the body, breast cancer, joints abnormality, and few types of heart problems, etc.

It is required for a patient to wear a gown before the MRI scan and all kinds to metal have to remove. If a patient has a magnet in the body this patient probably unable to have an MRI. During the MRI if the patient feels discomfort then it is possible to contact the technician via the intercom to stop the scanning.

Figure 3.3: Illustration of an MRI Machine [7]

Unlike the x-ray, it has no side effects and the rare case is that a patient experienced side effects because of the MRI scan. Besides that, the contrast dye can cause headaches, nausea, and pain, etc. [6].

MRI is the most common technique for diagnosing the brain tumor and it is widely using in the recent era of the technology. With the help of digital image processing, doctors can make the process easier to detect tumors, lesions and other abnormalities from MRI Scanned pictures.

3.5 Image Thresholding

Image processing is very important in automated image analysis. For the computer-based analysis image processing required an essential operation which is called image thresholding. There are many different ways of thresholding but the main operation is almost the same and that is converting a gray image into a binary image. In thresholding, the operation image is sectioned based on the gray level strength of pixels.

In this study, the thresholding procedure completed depending on the luminance label. The luminance label may vary between 0 to 1. And also the luminance label can have fixed by manual input. By replacing all the pixels in black and white to the input image by this way the thresholding can be done. Black and white depending on the fixed luminance label, if the pixel has higher the luminance value then it will have converted to white on the other hand if the pixel has lower luminance value compared to fixed inputted value then this pixel will convert the black. Black and white only means 0 and 1. The digit 0 means no light (dark pixel) or no luminance and 1 means high light (light pixels) or light luminance.

Thresholding is used as a primary step in many applications. The only restriction is the thresholding process creates only two classes. This segmentation is such a powerful technique because it shows objects in the dark background [19]. Threshold-based segmentation results in a binary image which is very much required for present virtual reality or artificial intelligence technique. The thresholding value varies into two types, the first one is global thresholding and the second one is local thresholding [23].

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When we want to make a binary image, we set a fixed single threshold value which is called the global threshold. Again, if we have few objects and the background, we need to set multiple thresholds and this threshold is called a local threshold.

3.6 Summary

In this section, I just discussed different brain tumors. From the tumor types, we can easily understand that the tumor is two types depending on the tumor source those are primary and secondary. Primary tumors grow inside the brain and the secondary tumors come into the brain from the other part of the body. But most accurately the tumors are also two types which are benign tumors and malignant tumors. Benign tumors are slow-growing and it has cancer cells. They can be life-threatening if they grow big inside of the brain and make pressure. Benign tumors can convert to malignant tumors [2]. Malignant tumors contain cancer cells. The tumor cells capable of attacking the neighbor cells around it. The growth of Malignant tumor is faster compared to benign tumors. Almost 40% of brain and spinal cord tumors are malignant [9]. And then we discussed the four grades of the tumor.

In the second section, we discussed the MRI technique and an illustration of an MRI machine. And a brief about MRI. Finally, I explained about the fundamental technique of the study and which is threshold-based segmentation. In this section, we can easily understand the thresholding applied in this study. This threshold is essential for digital image analysis; the main theme is to convert a grayscale image into a binary image that is capable of computer analysis. The threshold is performed on an image by varying luminance label. This label varies between 0 and 1. Consider the label is 0.5 that means pixels lower the luminance from 0.5 will convert to dark and greater than 0.5 will convert to white.

CHAPTER 4

METHODOLOGY

4.1 Introduction

This chapter recounts and consults about the research methods which is used in this study of the brain tumor detection process. The whole process can be separated into two-stage, the first one is pre-processing and the second one is post-processing. The first stage makes the image more suitable to analyze and easier for the second stage. The first one makes sure that the MR image contains a tumor or not after thresholding the image. The second stage contains the morphological operation and also the exact location of the tumor on the MR image, finding the visual area of the tumor and marking the tumor with a red boundary. The whole method described briefly in the flowchart (4.1).

4.2 Why MRI Image

The MRI technique is more accurate than other imaging methods. MRI can extract more details compared to others. We need to find a tumor in the brain image. The brain is more solid than other brain particles. The solid things on MRI are shown in bright but in most another method it seems dark. In figure 4.1 both images contain brain tumor but the tumor is visible in 4.1(a) image, on the other hand, the tumor is dark in 4.1(b) image. The harder part of the brain which is cranium and that is too bright in the CT image but dark gray in MRI image. Overall the MRI image is more helpful than CT and other imaging techniques. For the region, all data collected for this study is the MRI image.

More specifically the T-1 and T-2 weighted MRI is suitable for this study but T-2 has an advantage too. The majority part of the data is the T-2 weighted MRI image. The

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region behind it increased water, tumor and infection are bright is T-2 weighted image. Figure 4.1 (a) is the T-2 weighted MRI image.

(a)   (b)
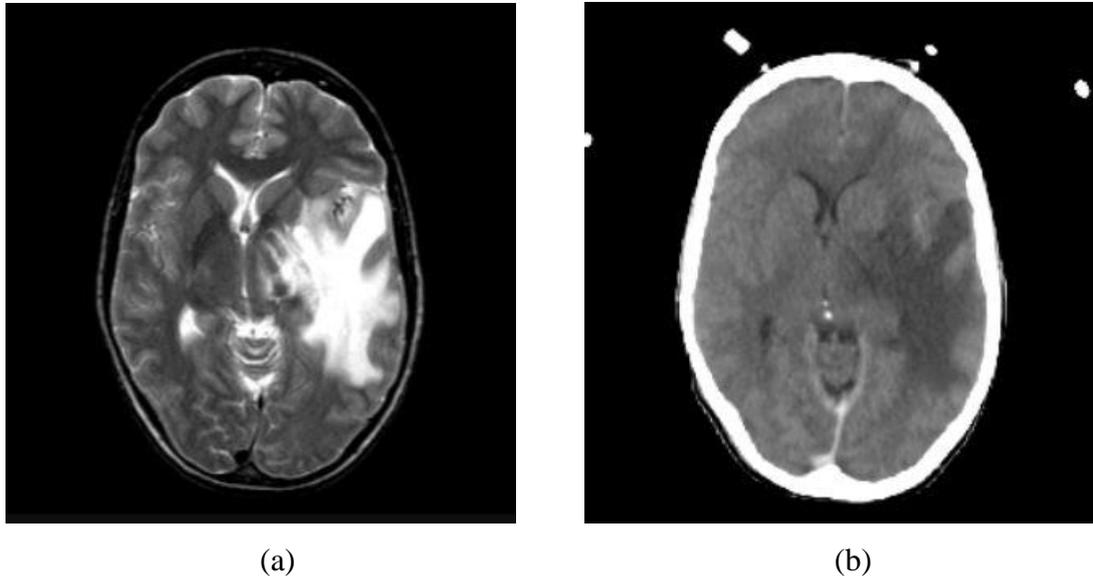
Figure 4.1: MRI (a) and CT (b) images of brain tumor

4.3 Database

In this study, the data is used from various sources. The whole brain atlas of Harvard University is one of them [44]. They have many resources and information available in public. Few university lectures from different corners of the world and other few web pages helped me to develop my database. The number of total data is 124 images which contain normal and abnormal brain images like with rumor of without tumors. The database contains both male and female's data, the age limit is approximately 20 to 80 years old patients. All the data varies between two formats while using the Matlab environment which is png and jpg. The database for this study are decorated into four types, the number of data is displayed with the types.

- i)   With Tumor (110)
- ii)   No Tumor (9)
- iii)   Can't detect (5)
- iv)   Few Varity

4.4 Method Flowchart

```
                           ┌─────────┐
                           │  Start  │
                           └─────────┘
                                │
                                ▼
          ┌─────────────────────────────────────────┐
          │   Image data acquisition from database   │
          └─────────────────────────────────────────┘
                                │
                                ▼
              ┌───────────────────────────────┐
              │        Threshold Image         │
              └───────────────────────────────┘
                                │
                                ▼
              ┌───────────────────────────────┐
              │        2-D Binary Image        │
              └───────────────────────────────┘
                                │
                                ▼
             ┌─────────────────────────────────┐
             │     Properties of image region   │
             └─────────────────────────────────┘
                                │
                                ▼
             ┌─────────────────────────────────┐
             │      Find the high density area  │
             └─────────────────────────────────┘
                                │
                                ▼
          ┌─────────────────────────────────────────┐
          │        Morphological Operation Apply     │
          └─────────────────────────────────────────┘
                                │
                                ▼
                      ╱─────────────────╲                    No
                     ╱   Is there any     ╲──────────────────────┐
                     ╲     tumor?         ╱                       │
                      ╲─────────────────╱                        ▼
                                │                        ┌─────────────────┐
                                ▼                        │    No tumor      │
                            ╱───────╲                    │ (Popup message)  │
    ┌─────────────────┐    ╱         ╲                   └─────────────────┘
    │ Tumor detected  │◄───╲   Yes   ╱                            │
    │ (Popup message) │     ╲───────╱                             │
    └─────────────────┘         │                                 │
                                ▼                                 │
         ┌─────────────────────────────────────────┐            │
         │   Mark the probable tumor zone with a box │            │
         └─────────────────────────────────────────┘            │
                                │                                 │
                                ▼                                 │
         ┌─────────────────────────────────────────┐            │
         │   Mark the exact tumor position on MR Image│           │
         └─────────────────────────────────────────┘            │
                                │                                 │
                                ▼                                 │
         ┌─────────────────────────────────────────┐            │
         │    Identified the exact tumor and show it.│            │
         └─────────────────────────────────────────┘            │
                                │                                 │
                                ▼                                 │
                           ┌─────────┐                           │
                           │   End   │◄──────────────────────────┘
                           └─────────┘
```

Figure 4.2: Process flow of proposed methodology

4.5 Preprocessing Stage

In this stage image preprocessing is occurred on MRI images. Without going directly to the operation I had done a few pre-preprocessing on all of my data. All the data that I collected from various sources some of them are in gray and few were in RGB format. Then it makes contradictory while working with them. For that issue, I converted all the colored images into the gray format by applying the 'rgb2gray' command of Matlab. And this operation I have done separately. After converting all data in the gray format then I have applied preprocessing and post-processing on my MRI images. And for this study to get a better output, it is required that data must be in a gray format not in RGB format. Sometimes this study works on colored data but it totally depends on image quality but the gray image is more suitable then RGB. The Matlab command is given below.

$$img = rgb2gray\,(im) \dots\dots\dots\dots\dots\dots\dots\dots (1)$$

Where, im is the main RGB image, and img is the converted Gray image.

4.5.1 Preprocessing

The preprocessing stage of this study is used to convert the image into a binary image by thresholding the input image and this is one of the segmentation techniques. After that convert the image into label connected components in a 2-D binary image, and then extracts the properties of the image to find the area and the solidity of the whole binary image.

4.5.1.a Segmentation

Brain image segmentation is a complex procedure in medical imaging but still, there are few methods to perform segmentation. The segmentation is performed depending on the thresholding operation. Thresholding depends on the luminous level. The height and lowest value of the luminous label are 0 and 1 respectively. In the thresholding operation, all the pixels replaced in black and white pixels so we can say it as a binary image or thresholded image. The reason for calling it the binary image is, the black and

white are actually pixels replaced into 0 and 1, the white pixels mean 1 luminous (light) and the black pixels mean 0 luminous (dark) on that image.

For this study the threshold value is 0.7, the higher the value of 0.7 then the pixel turned into white and lower the value of 0.7 then the pixels turned black on the image. The reason behind it, is the T2 weighted MRI image and the solid part of the brain is white and the liquid part of the brain is black. We know that the tumor is more solid than the brain, for that reason I applied a threshold to remove the nonsolid particles from the brain and it only contains the tumor and other solid parts of the brain. The only motive of segmentation is to find the tumor and the background on the MRI image. The value of threshold (T) is calculated by the mean gray label in the equation (1).

$$T = \frac{\sum_{x=1}^{M} \sum_{y=1}^{N} f(x,y)}{M \times N} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (2)$$

Where $f(x, y)$ represents the gray label of pixels in the x and y coordinates in the MRI image and the $M \times N$ represents the size of the MRI image.

$$f_x(x,y) = \begin{cases} 255, & f(x, y) \geq T \\ 0, & f(x, y) > T \end{cases} \dots\dots\dots\dots\dots\dots (3)$$

In the equation number 2, f(x, y) represents a binary image or thresholding image.

4.5.1.b Properties Extraction

As we know from before, the solidity of the tumor is more than the brain itself and it is required to find the exact tumor area. After the thresholding now measures the properties of image region like Area, Bounding Box, Centroid, Equivalent Diameter, Euler Number, Pixel List, and Solidity also many more. By this operation, it is easy to find the area and solidity of the MRI image and it makes easier the farther operations to find tumor from MRI image. Finally, it is easy to find the density from the solidity of the MRI image. This feature extraction is done by a Matlab command which is 'regionprops'. This operation is not only can find features of an MRI image but also it can do the 'pixel value measurement'. To perform pixel value measurement, it required

a grayscale image as an input. The examples of pixel value measurement are Maximum Intensity, Mean Intensity, Minimum Intensity, Pixel Values, and Weighted Centroid, etc. The Matlab function is used for this operation is given bellow.

$$h = regionprops(label,' solidity',' area') \dots\dots\dots\dots\dots\dots (4)$$

Where 'label' represents the 'label connected components in 2-D binary image'. And the 'solidity, area' is extracted feature from the image.

4.6 Post-Processing Stage

The post-processing stage which is applied in this study is used to find the region of tumor from MRI image. Some process like finding maximum high-density area, finding the exact tumor, morphological operation and most importantly the decision making about is there any tumor or not in the MRI image those are obtained in the following paragraph.

4.6.1 High Density Area Finding

The first task of the post-processing stage is to find the pixel density of the MRI image. As we know the solidity of the tumor is more than the brain itself so the density of the tumor region will be high compared to the other brain organ or nerves. The maximum high-density area inside of the skull probably the brain tumor. In this study, I applied density above 0.54 as a high-density value to find the high-density area. It means, density more than 54% of the brain will be the high-density area from the thresholded image. From the properties 'area' of the thresholded image which is extracted in the preprocessing stage the maximum high-density area is also extracted. Most probably one of the maximum high-density areas will represent the tumor.

In most of the case after applying this operation in the thresholded MRI image the output I got the tumor. If this maximum high-density area is the member of label connected components in a 2-D binary image, then it is sure that it is the tumor. But the

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tumor is like the initial brain pictures tumor as we can see in a normal vision on MRI image, which contains small pixel missing or shading or other small particles on the tumor which is not clear. To make the tumor more visible and more accurate it needs to apply the morphological operation.

4.6.2 Tumor or No Tumor Sensing

It is so important task to decide on 'there is any tumor or not'. If there is a tumor on the image, then farther analysis does require and it will be the fruitful work but on the other hand, if there is no tumor all analysis will go wrong and the time will waste for that the decision making is made more sense and it has importance too. By depending on the area and maximum high-density area from the extracted featured image, it makes an important decision about is there any tumor or not on the MRI image. It performs a logical if-else operation and the output which I got is more accurate for my all data. This decision making is required less than half-second. If the tumor is detected then the morphological operation is executed with few more operations, before those operations the system will show the popup message "Tumor Detected" and will show the all required image variations with the tumor. If the tumor is not detected, then the system doesn't do any farther operations and only shows a popup message containing the information "Tumor is not detected" and will show the main input image.

4.6.3 Morphological Operation

There are many types of morphological operations of different applications, like opening, closing, erosion, and dilation, etc. The main purpose of those operations is to withdraw the small holes, hurdles and other particles from the image [12]. It dilates the grayscale, binary or packed binary images and returning the desired dilated image. The condition for the dilation is: according to the Matlab image processing toolbox user guide, "the value of output pixel is the maximum value of all pixels in the input pixel's neighborhood. In a binary image, if any of the pixels is set to the value 1, the output pixel is set to 1". Dilation adds pixels in the required zone of an image, the number of pixel addition depends on the element called structuring element.

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$$X \oplus B = \{ c = x + b \in Z^2 : x \in X; b \in B \}. \ldots \ldots \ldots (5)$$

The dilation operation is performed according to the equation (5), this equation is a mathematical expression of dilation operation. Let consider the equation (5) where X is the image and B is the structuring element, 'X⊕ B' is the output of dilation which is a dilated image. Vector x and b are belonging to the set X and B and Z2 is discrete space [45].

This operation is performed by a Matlab command called "imdilate", which is shown in the following expression.

$$f_d(x, y) = imdilate(f(x, y), E) \ldots \ldots \ldots \ldots \ldots (6)$$

Where $f(x, y)$ represents the binary image and $f_d(x, y)$ represents the dilated image output and finally the argument E stands for structuring element.

A property called structuring element is required for the morphological operation. The structuring element is set to all possible zone in the MRI image and it makes a comparison with the respectable neighborhood of pixels [41]. There are many types of structuring elements like square, line, disk, and ball. In this study, I have used 'disk' as a structuring element. The work of structuring element and dilation is illustrated bellow.


Figure 4.3: Illustration of morphological operation (Dilation)

The expression for structuring element is given bellow.

$$E = strel('shape', r) \ldots \ldots \ldots \ldots \ldots \ldots (7)$$

Where, 'E' represents the structuring element and the 'shape' is the shape of the element, for this study the shape is 'disk' and the 'r' is the radius for the disk. Also, the disk radius is '5' for this study.

4.6.4 Boundary Making

This function is for making a boundary around the tumor on the main MRI image. To make ensure that is the tumor while viewing the MRI image this function is more useful for it. The color of the boundary around the tumor can be red, yellow, green, blue, black and white, etc. For this study, the used color is 'red'. The Matlab function is used for this operation is given bellow.

$$[B, L] = bwboundaries(BW, 'options') \ldots \ldots \ldots \ldots \ldots \ldots (8)$$

Where 'B' represents the length of the path where the boundary will be plotted and the 'L' represents the label matrix. The parameter 'bwboundaries' trace the region boundaries in a binary image. 'BW' is the binary image where the boundary will be plotted. And finally, the 'options' denotes that, it can take an optional string input like 'noholes' and 'holes'. According to Mat works, 'the string 'noholes' speeds up the operation of the algorithm by having it search only for object (parent and child) boundaries. And also the string 'hole' the algorithm search for both boundaries and objects, and this is the default operation'. Finally, a loop is applied to draw the boundary around the desired object.

4.6.5 Bounding Box Making

This function is for making a rectangle box around the tumor. This is done by the feature extraction property used before in this study. The feature called 'bounding-box' is

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extracted and applied to make a box around the tumor region. The color of the boundary around the tumor can be red, yellow, green, blue, black and white, etc. For this study, the used color is 'red'. The Matlab function is used for this operation is given bellow.

$$Box = regionprops(image, 'boundingbox') \dots\dots\dots\dots\dots\dots (9)$$

Where 'boundingbox' is the feature that is extracted from the image. By using this extracted feature, a loop is applied to make the box around the desired object.

4.7 Summary

In this section, the overall method is discussed in detail. Also, the flowchart and database are discussed. First of all, in the database section, it is mentioned where the data of this study comes from. And secondly mentioned the complete flowchart diagram in a step by step. Thirdly the preprocessing and post-processing stage is discussed in detail.

Different operations and other feature extraction properties are discussed in the pre-processing and post-processing stage. Also, the equations of those operations are given with the section.

CHAPTER 5

RESULT AND DISCUSSIONS

5.1 Introduction

This chapter presents the analysis and results of this study. The total process is successfully applied in the Matlab version R2015a using the image processing toolbox. Every output of the Matlab from every section is discussed in later sections with a suitable figure.

5.2 Result of Preprocessing Stage

At the beginning of the preprocessing, the study has done a pre-preprocessing operation that is not included in the original method of this study. This study does require a gray image as an input, all data of the database of this study are in gray format. This RGB to Gray conversion is done in another workplace of Matlab and after that, the converted image is used as an input of this method in this study.

(a)   (b)
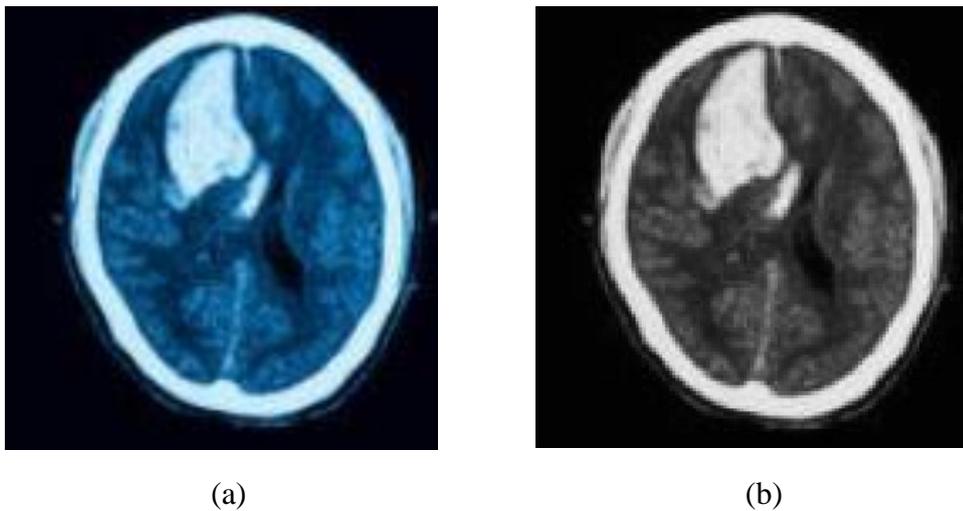
Figure 5.1: Illustration of color image and Gray image

In figure 5.1(a), it is the color MRI image I have collected from one of my data sources and figure 5.1(b) is converted image in gray format.

5.2.1 Result of Preprocessing

In this process first of all the system require input data to perform the rest of the processing. Four MRI gray image which is shown in figure 5.2 is considered as input in this paper. From my database, this four images to be analyzed in the next analysis and will be shown the results to carry ahead the result and discussion chapter.

(a)   (b)

(c)   (d)
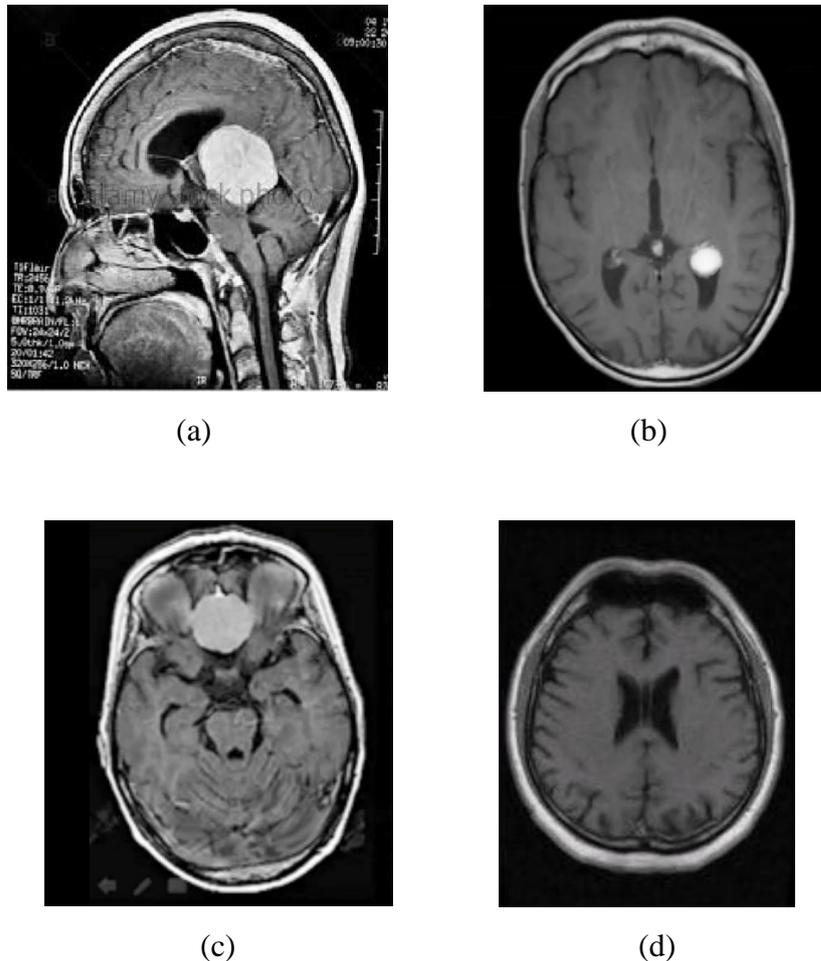
Figure 5.2: Input images

Figure 5.2, all four images are in gray input data for this study. Figure 'a', 'b' and 'c' have a tumor on it and figure 'd' has no tumor on it. Figure 'a' and 'c' has a large tumor and 'b' has a small tumor on it.

5.2.2 Result of Segmentation

After segmentation of the input images is in figure 5.3, the segmentation is based on thresholding. The thresholding level varies between 0 and 1, in this study this value is 0.7, to make the image reliable to find the tumor this value is suitable and more accurate. In this thresholded image, we can see only black and white pixels are available. From this binary image easily the tumor to be founded by removing the other particles from it. If we search for the maximum high-density area from this thresholded image we will get the tumor because the tumor is more solid than the brain particle and to be more solid, it has to be denser in particle.

(a)   (b)

(c)   (d)
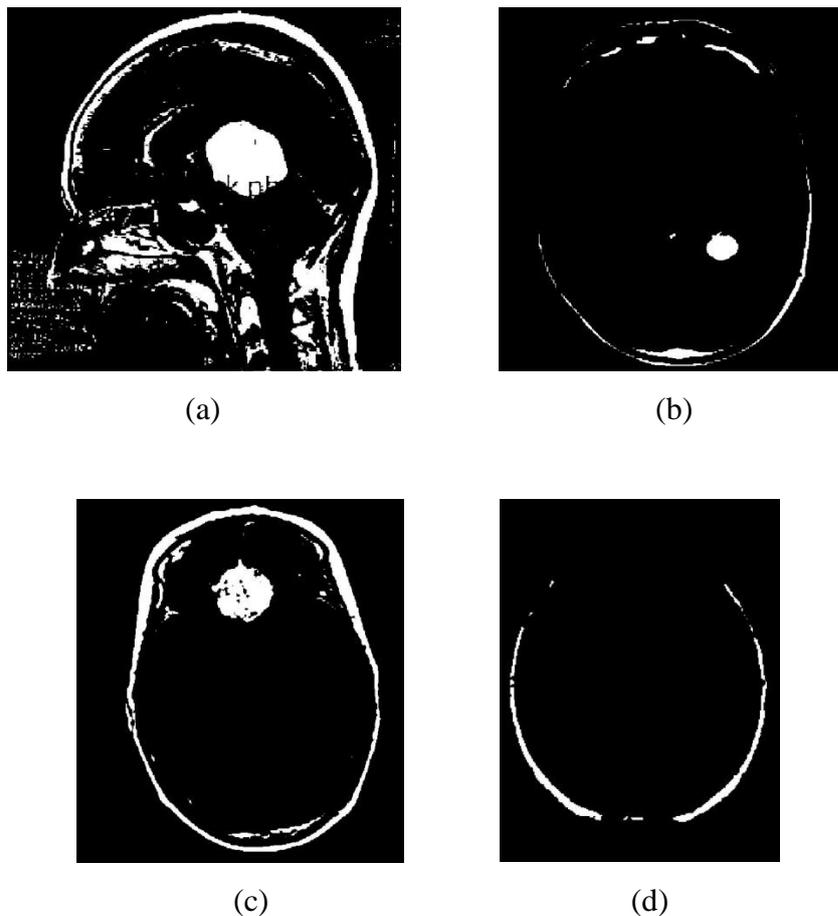
Figure 5.3: Thresholded image

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In the figure, 'a' the tumor is easily views but cranium and other particles can be seen. In the picture 'b' tumor and cranium are shows but noise is less than the picture 'a'. picture 'c' is similar to the picture 'b' and picture 'd' is shows that it has no tumor on it. So this thresholded image is ready for farther processing.

5.3 Result of Post-Processing Stage

The results of the post-processing stages are discussed in this section with individual illustration and analysis. The details method is discussed in the methodology section, which is section number 4.6, and this section is the result of this section. The post-processing stage contains few steps those results are bellow.

5.3.1 Result of High Density Area Finding

In this section, the output of high-density area finding which is discussed in the section of 4.6.1 is shown for all four inputs of this study. And we will see that this is the desired output of this study because this result gives us the tumor from MRI images.

|	
(a)	(b)
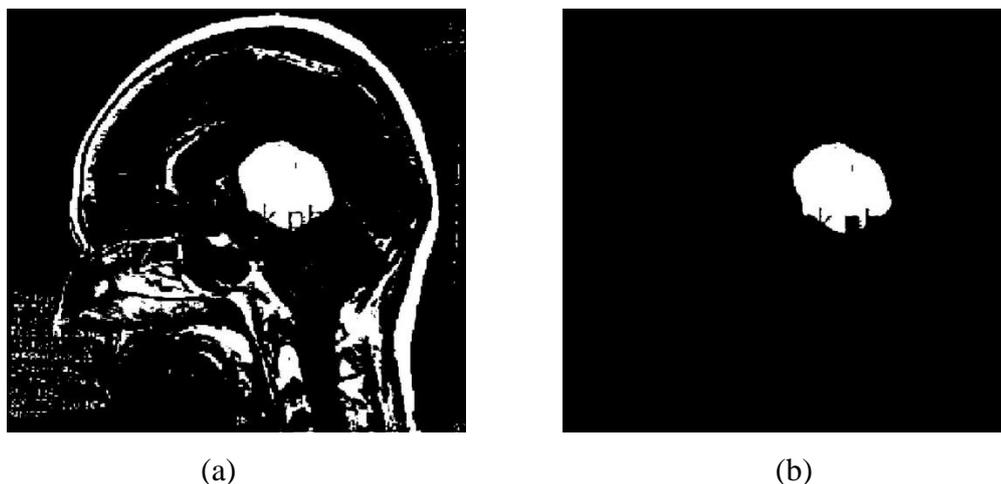
Figure 5.4: High density area of first input.

In figure 5.4 the image 'a' is the binary image and the image 'b' is the high-density area of this binary image and this is the output which is our result and desired tumor. In the

next operation, the tumor will be more polished for making a better view. So the tumor is finally detected and this decision is to be presented in Matlab workplace by a popup message, to make sure the user that patience has a tumor in the brain.


(a)   (b)
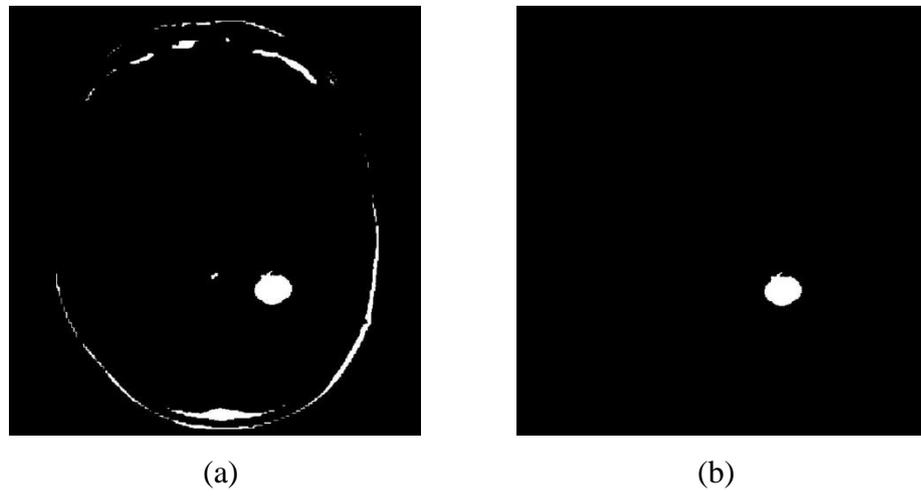
Figure 5.5: High density area of second input.

Similarly, in figure 5.5, 'a' is the binary image and 'b' is the high-density area of it. By this process, one thing is very clear that the only tumor contains a high-density area. For that reason, the tumor area is extracted from the thresholded image.

(a)   (b)
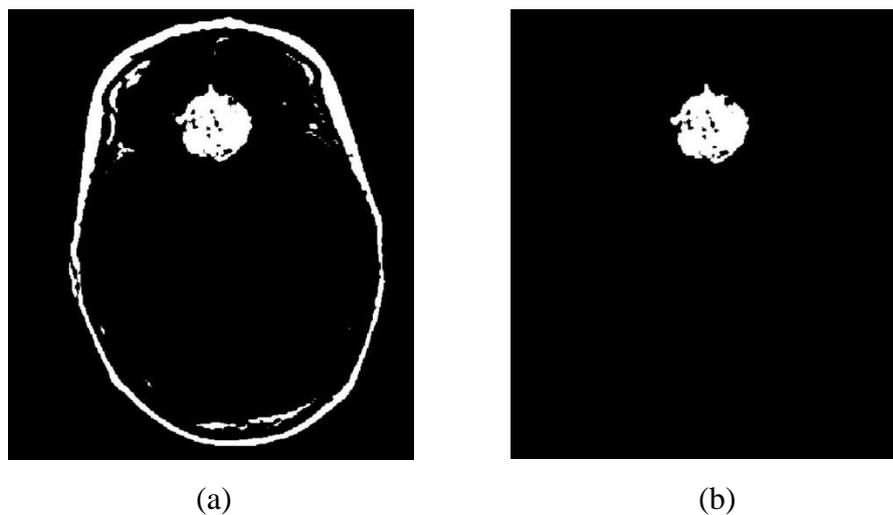
Figure 5.6: High density area of third input.

As we know from before this figure is not anything like different from before. Figure 5.6 'a' is binary and figure 5.6 'b' is the high-density area of it. But this high-density area has small holes and some dark pixels on it. If we want to show the tumor-like polished, then all we have to do a morphological operation called 'dilation'.


(a)   (b)
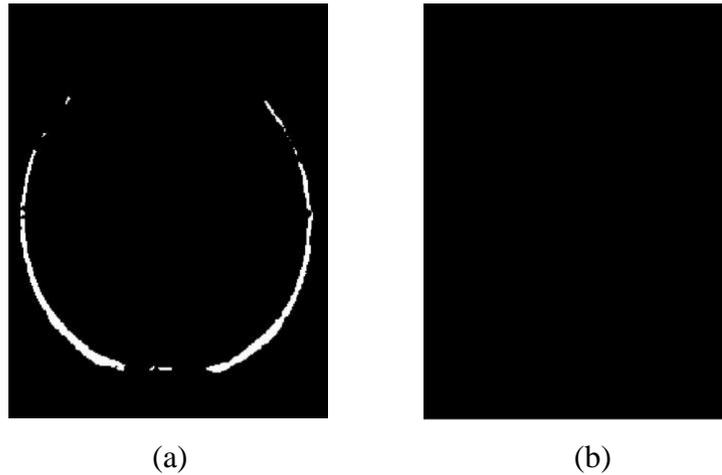
Figure 5.7: Output of 4th input in High density area finding

We know from before the fourth input for this study has no visible tumor on the MRI image. In figure 5.7, 'a' denotes the binary image of the fourth input and figure 'b' is the output in this section and this threshold image has no high-density area above 54% of brain density. This is clear that technically it is possible to make a decision that input four has no tumor and this decision to be shown in Matlab workplace by popup message.

5.3.2 Result of Tumor or No Tumor Sensing

In this section, the result of the 4.6.2 section called 'Tumor or No Tumor Sensing' is plotted. This is considered a huge important term of this study that making a decision about it. The papers which were followed for this study had no confirmation like it.

If MRI image has tumor on it then show the figure 5.8(a), which indicates "TUMOR DETECTED" that means the input data has the tumor, on the other hand, if the image

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did not contain tumor then the figure 5.8(b) will be shown, which informs the user that "NO TUMOR" on the input image.


(a)   (b)
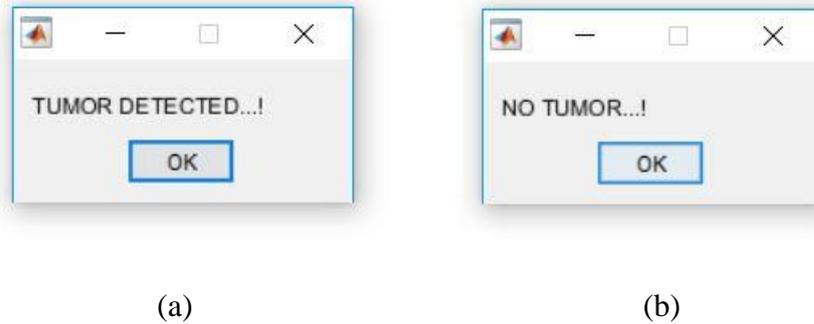
Figure 5.8: Popup messages

5.3.3 Result of Morphological Operation

In the section 'result of the high-density area finding' section number (5.3.1), the tumor has holes and dark pixels. This problem is not in every case as an instance the input two has no problem but input one and input three have this problem. Input three has more problems than input one.

(a)   (b)
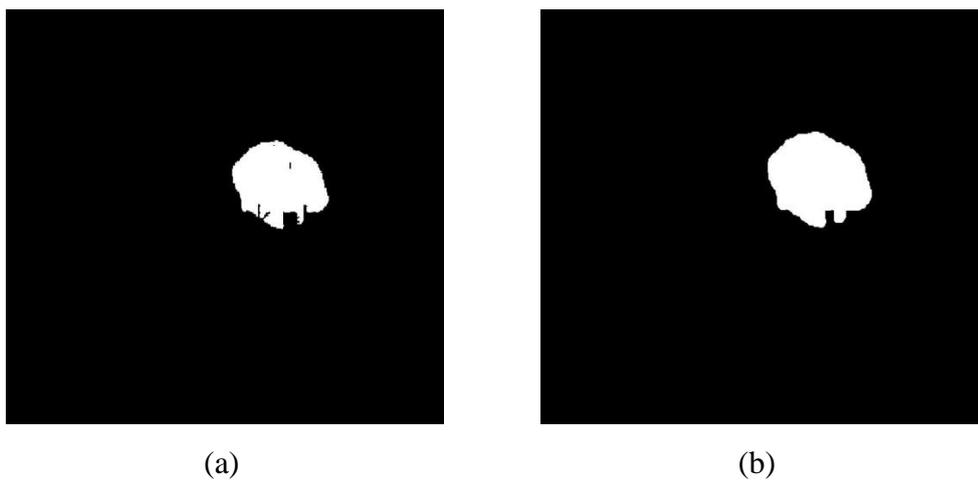
Figure 5.9: Tumor with and without dilation - Input I

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Morphological operation is discussed is the section of 4.6.3, the result of this section will be shown. In figure 5.9, we can see the tumor of input 1, figure 'a' is tumor extract from MRI image but this image has some other particle in it. To make more polished and to look better the morphological operation is applied. The result of morphological operation specifically dilation operation is figure 'b'. Figure 'b' is more polished then figure 'a' and it looks more acceptable.


(a)   (b)
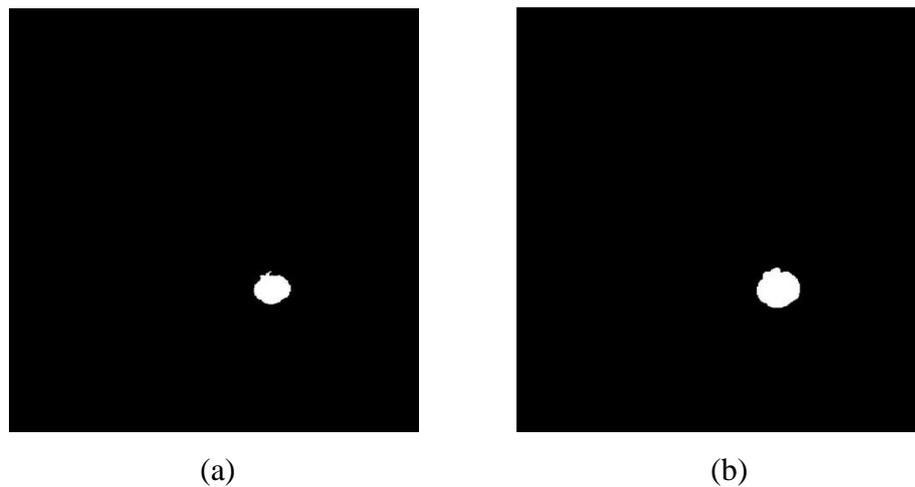
Figure 5.10: Tumor with and without dilation – Input II

Similarly, in figure 5.10, 'a' is the not dilated and figure 'b' is the dilated image. In this case, the output is not huge changed even the input has even no dark pixels or holes on it. The output is very similar except for the outer area of the tumor. The outer area is smooth and looks good.

In figure 5.11, the tumor has many dark holes and pixels on it. The dilation operation is applied to solve the problem and the acquired result is really very good because after dilation the tumor has not even a single dark pixel or hole, it is completely clean and sharp 'figure b' which looks very good then the input.

(a)   (b)
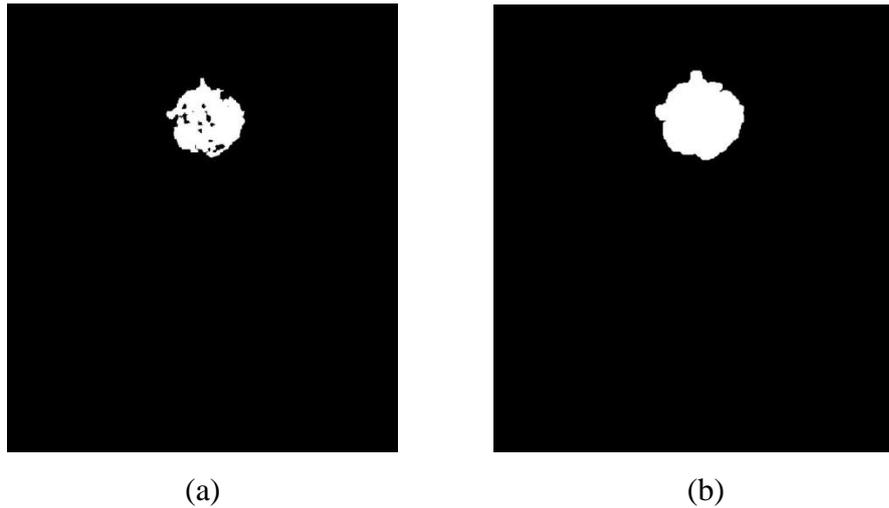
Figure 5.11: Tumor with and without dilation – Input III

5.3.4 Result of Boundary Making

This discussion is done in the section of 4.6.4 and here is the result after applying this operation to the input images.

(a)   (b)   (c)
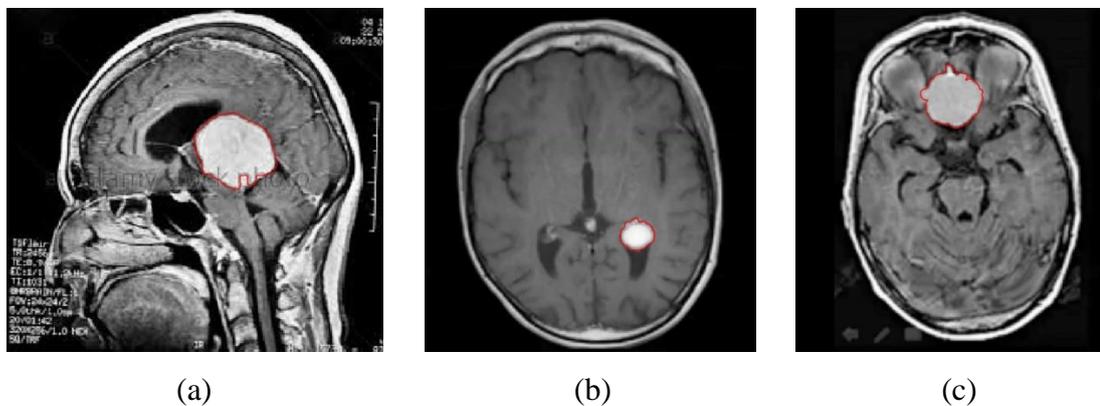
Figure 5.12: Illustration of bounded tumor on MRI image

In figure 5.12 we can see all input images has a red boundary around the tumor area. This red boundary-making is sure that the tumor exactly inside the red circle, in other words, it is the tumor.

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5.3.5 Result of Bounding Box Making

This discussion is done in the section of 4.6.5 and in this section the result is shown with an illustration.


(a) (b) (c)
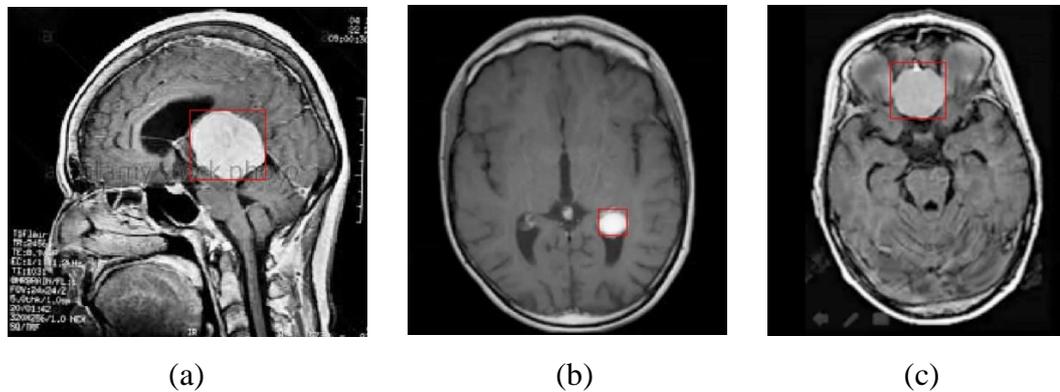
Figure 5.13: Illustration of tumor with bounding box

In the picture of 5.13, we can see the tumors of all input images with a red boundary around it. This boundary represents the zone of the tumor but not exactly circular, it is a rectangular boundary.

5.3.6 Final Output

At the very beginning of this chapter four images introduced as input images for this study. In this subsection, the final output for all of the inputs will be shown one by one.

In figure 5.14, 5.15, 5.16 represents the output of input I, II and III respectively. These three images have a tumor and the output brings the main image, binary image, tumor with and without dilation, detected a tumor on MRI image and bounding box image in one plot, and finally above those all a popup message denotes that the system detects a tumor on input MRI image.

Figure 5.17 represents the output of the 4th input MRI image. It shows the main image and binary image in one plot. Above those two images, a popup message is displaying that 'No Tumor' on the input MRI image.
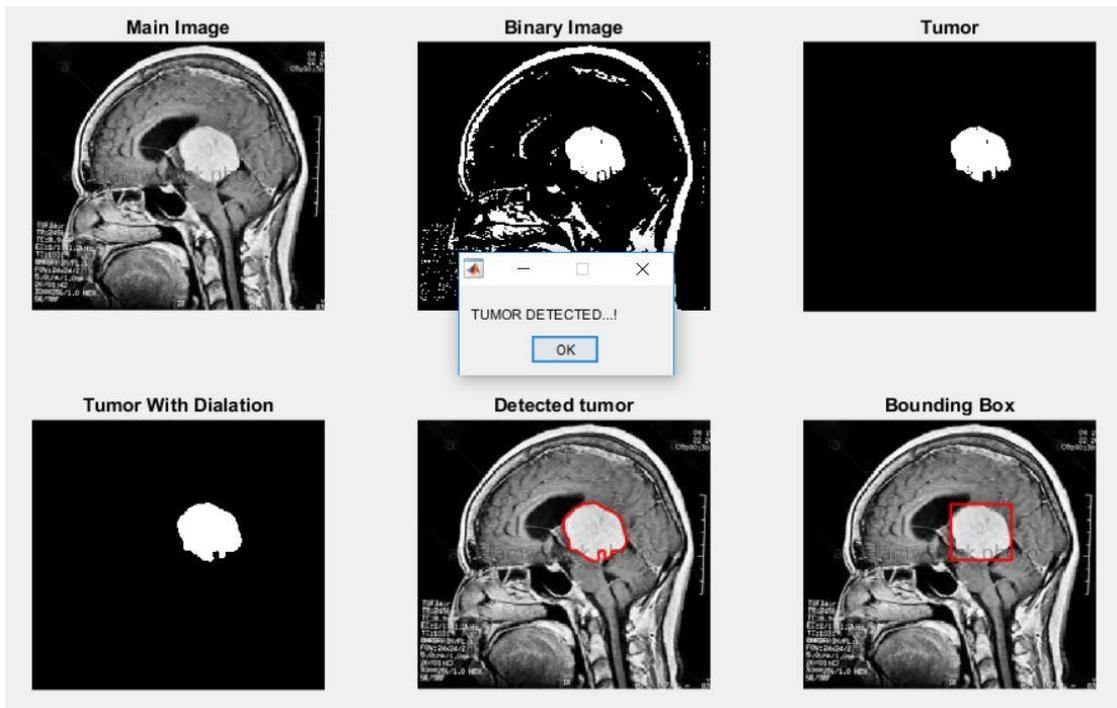
Figure 5.14: Final output for input I.
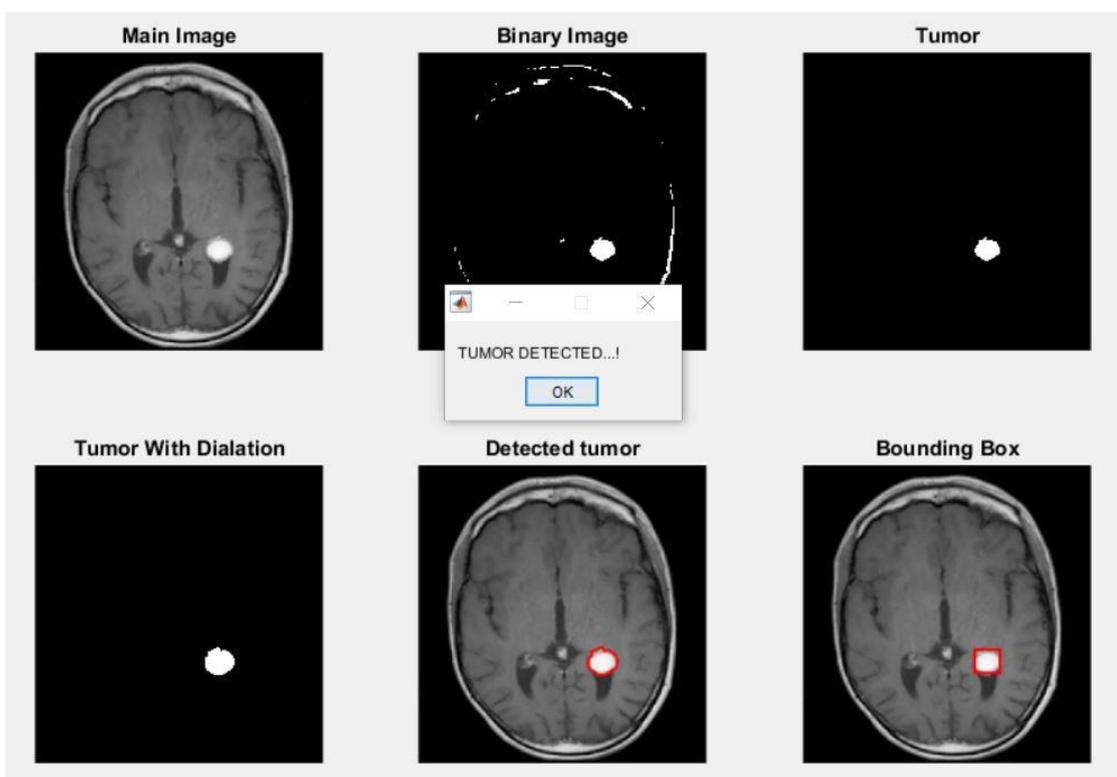
Figure 5.15: Final output for input II.
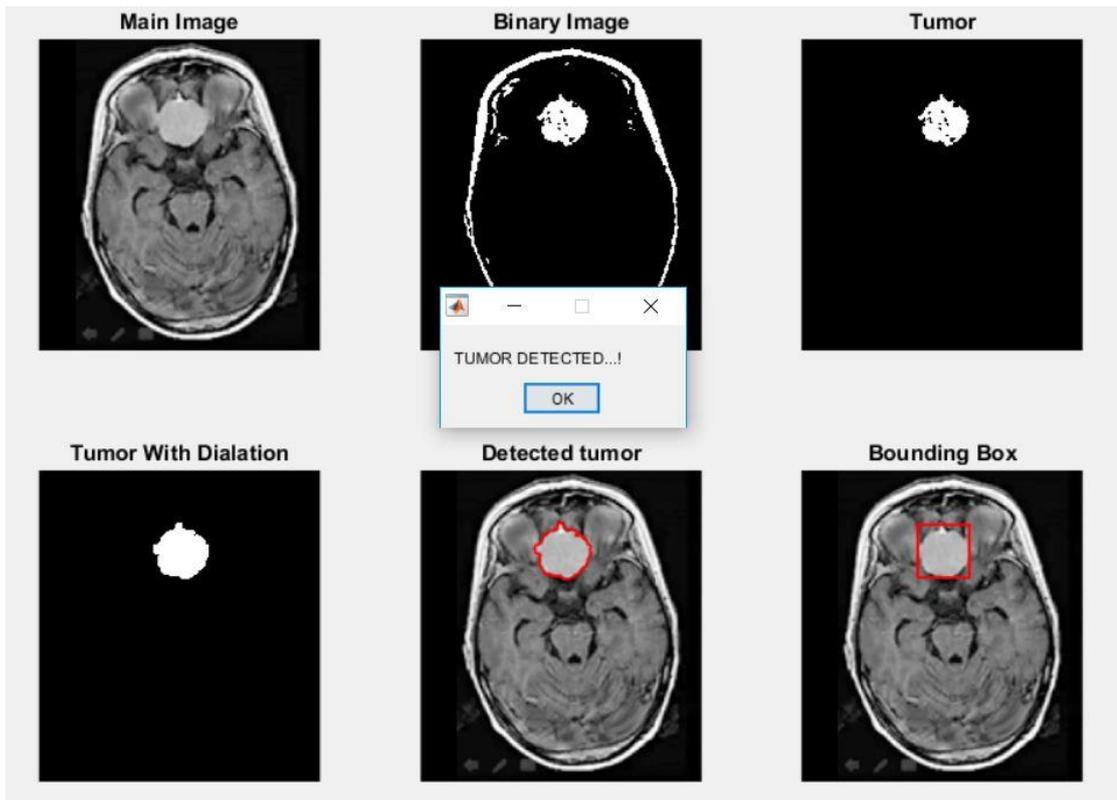
Figure 5.16: Final output for input III.

Figure 5.17: Final output for input IV.

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5.4 Accuracy of the Result

The accuracy is how close the acquired value to the real value [12]. In this study, the total number of data is 124. Among them 110 data have a tumor on them, 9 data have no tumor on them and 5 data which can't detect by this system. After applying the operation to all the data, the system gives the accurate result for 119 data and the remaining data not to be detected accurately in this system. Those 5 data need farther analysis to make better results of this study.

$$Accuracy = \frac{Number\ of\ correct\ data}{Number\ of\ total\ data} \dots\dots\dots\dots\dots\dots\dots\dots .(8)$$

$$Accuracy = \frac{119}{124} * 100\%$$

$$= 95.97\ \%$$

5.5 Discussion

The data is collected from various sources and some of them were gray and some of them were in RGB format. To increase system performance, the data needs to be in one format. For that reason, all data are converted to a gray format which is discussed at the very beginning of the section of 4.4, and how this is performed also that is discussed. Because of this conversion, the information does not lose a huge from the images, if huge information is lost then the quality might be very low of those images. But it does not happen.

In section 5.3.3 the result of dilation operation is very satisfying for the images in figure 5.9 and 5.11 but for figure 5.10 the result of dilation was very close to the main image. The most probable reason behind it the solidity of the tumor in the main image was very high as a result the tumor in the threshold image comes very brightly because the operation of thresholding is it.

Finally, section 5.4 evolves the final result with accuracy. The accuracy is most important for any study and in this case, the accuracy is 95.97% which is good for this study. This result comes after applying the method to 124 samples and if all the MRI images are good in resolution and image quality then the accuracy will be more and I am very hopeful about it. The proposed method and the algorithm give an acceptable result according to the accuracy and overall performance.

CHAPTR 6

CONCLUSIONS

6.1 Conclusions

This thesis aims to design an automatic system to find tumor from MRI brain image using Matlab image processing toolbox. The system has been successfully designed and applied to all data. The data is collected from various sources and organized by preprocessing and post processing operation to make it appropriate to detect.

The image is converted to gray and thresholded with a certain suitable value. The analysis called statistical feature analysis was used to extract few important features from MRI image. Then select very important two feature which helps to find tumor from image. In the middle of processing the system decides that the image contains tumor or it has no tumor and this important decision shows to the user immediately. When the system detects tumor then extract it from image and take steps to farther operation. After all the operations the system shows all the important outputs in one plot.

Finally, the proposed method which is based on thresholding segmentation process become successfully tested and achieved the best result with accuracy 95.97%. All the important outputs like isolated tumor, tumor indication on main image and few more.

The brain tumor detection from MRI image is successfully implemented and tested by using image processing tool box of Matlab.

6.2 Limitations of the Work

Initially, the major problem was finding free data resources. If I could apply this method to many data like 300 or 500 data, then the result would be more accurate. It is so important to making a database for this kind of research for free of cost. Many researchers get tired and frustrated by finding data resources to work with and by doing this they get demotivated. And the second thing about the data is 'quality data', sometimes few data have already lost its image quality and much information from it, then by doing farther analysis the data don't give a suitable result and make a totally waste of time. In this thesis the 5 data which was very low of a resolution and already lost their information and because of this it could don't detect by this method.

This thesis needs to classify the tumor-like the types of the tumor because the diagnosis of a brain tumor depends on the detection of abnormal brain structure and types of the tumor. Also, early detection is a factor of diagnosis. The diagnosis is a very important and sensitive task therefore the accuracy contains much importance.

6.3 Future Scopes

In the future, this study can be developed by adding more features to it. Segmentation processes can be increased with the threshold-based segmentation. Water shade segmentation can be added. The feature extraction process is used but only three feature is used to detect the tumor. By collecting more effective features from the feature extraction properties this study can be more reliable and effective and also the accuracy will be higher.

This study can be added with some kind of early detection process. Early detection is a challenge for the therapist. Early detecting and diagnosing can prevent unexpected death.

If somehow the lost information of an image can be collected or developed and apply this study on it, the accuracy will be higher than before. In this case, the challenge is to convert a low-resolution image into a high-resolution image. Once it did also with that the accuracy of this study will be increased.

This system can farther be used for different pathological diesis to classify the images for diagnosis and research.