Brain Tumor Detection from MRI Images using Image Processing

Md. Ariful Islam, Tanjima Akhter, Amena Begum, Md. Rakib Hasan, Farzana Sultana Rafi

Abstract: ***Brain Tumor has become one of the common diseases in the world which can be characterized as the unhindered expansion of atypical cells in brain and when compared to tumors in other areas of the body, it gives rise to a challenge for diagnosis. But in the development of this disease along with the well-established image processing system, diagnosis becomes much easier. The thrust of this project is to provide possible methodology for detecting size and region of tumor quickly from MRI image using region splitting, merging and growing based segmentation process within a short span of time. The whole process includes five stages namely Input as MRI images, preprocessing, enhancement of the image, image segmentation, feature extraction and classification of the tumor within boundary. Upon collection of MRI image, contrast enhancement and median filtering have used for enhancing the image and then segmentation process have done to detect the brain tumor. Graphical user interface has used for organizing input-output data and the algorithm has been designed by using MATLAB.***

Keywords*: *MRI, GUI, Segmentation, Brain Tumor, Filtering, Enhancement, MATLAB.

I. INTRODUCTION

The human body is comprised of various types of cells where brain plays the role of most significant portion. It is also known as the kernel of the central nervous system [1]. Brain Tumor is the unhindered expansion of atypical cells in brain that sprout out of control of the normal forces that regulates growth. As the brain is enclosed by a rigid structure known as skull, so any ontogenesis inside such a compact space can cause severe problems. Brain tumors can be cancerous or non-cancerous. Tumors can cause pressure inside skull or skull to increase which leads to brain damage like interruption in brain's ability to work normally or it can also be life threatening doesn't matter whether cancerous or non-cancerous [2].

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There are three types of brain tumor namely Benign tumor, Pre-Malignant tumor and Malignant tumor [3]. Brain Tumor has become one of the common diseases in the world. One of the major causes for the increase in mortality among adults and children is brain tumor. There are two general categories of complex brain tumor depending on some factors like origin, growth pattern and malignancy. Tumors which arise from cells or from covering of the brain known as primary while secondary or metastatic brain tumor occurs when cancer cells spread to the brain from a primary cancer in another part of the body and form secondary or metastatic brain tumor [4]. Brain tumors do not discriminate, and they tend to affect all regardless of ages, genders and ethnicities. More than 700,000 people of America are now living with brain tumor today among them nearly 80,000 people are having treatment for primary brain tumor this year. More than 120 several types of primary brain and CNS tumors have been identified. A study says almost 16,000 people will die as a result of brain tumor this year [2].

Now-a-days using image processing tumor detection process becomes much easier than ever. The detection of brain tumors is comprised of detecting the affected area as well as shape, size and position of the tumor. Magnetic resonance image (MRI), computed tomography (CT) and Positron Emission Tomography (PET) are well known imaging technologies for detecting tumor. MRI and CT scan have been the most frequent while testing anatomy of the brain tumor [1]. However, the detection process and processing time may vary under different circumstances and segmentation result also can vary because of the brightness and contrast of the display screen. That's why automatic brain tumor detection tends to play a remarkable role in medical science [3].

The probability of survival of a tumor increases as of using automatic detection. In order to identify brain tumors automatically with better accuracy, exactness and speed of computation by minimizing manual effort several research works are going on. This paper has proposed a possible methodology to ameliorate the automatic detection of size and region of tumor from MRI image within a short span of time with better accuracy. For this work, segmentation algorithm has implemented in order to determine the best amalgamation of information draw out by the chosen criterion. The whole process is comprised of five stages namely input as MRI images, preprocessing, image enhancement, image segmentation, feature extraction and classification of the tumor within boundary.

Upon collection of MRI image, contrast enhancement which is the process of adjusting images has performed so that they can be better while displaying and noise will be removed by median filtering.

Segmentation method has performed based on region splitting, merging and growing approach of pixels. Then to separate the tumor part of the MRI image, morphological operation has applied.

II. METHODOLOGY

For detecting brain tumor cell automatically, the proposed methodology flow chart is given in figure 1. There are five steps which are acquired in brain tumor detection such as

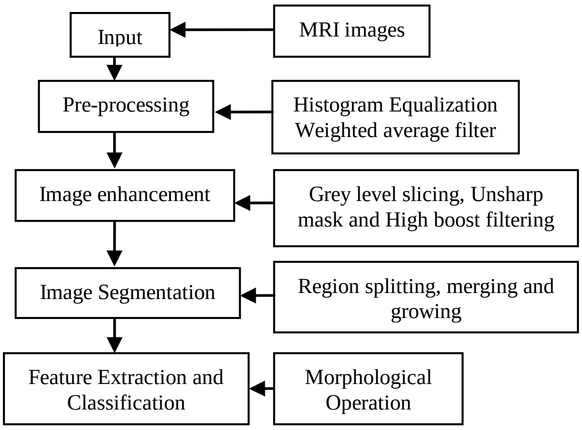
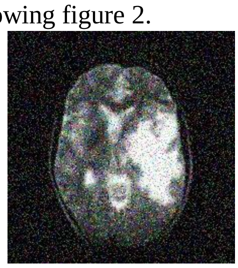


Fig-1: Proposed methodology for brain tumor cell detection automatically

A. Input as MRI image

A 3-D detailed picture of the brain structure has created by magnetic resonance imaging (MRI) scan (interaction of magnetic field and radio waves) which is painless and noninvasive process. In this process, MRI images are retrieved with noises from MRI machine shown in the following figure 2.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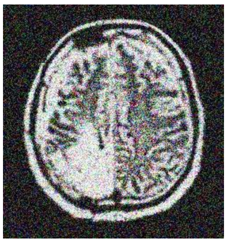
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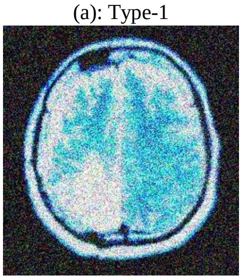

(c): Type-3

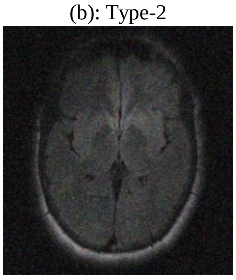

(d): Type-4

Fig-2: Various types of MRI images from MRI machine

B. Pre-processing

In this step, noise has removed from the MRI images by performing image filtering techniques such as histogram equalization by which the intensity has distributed equally and then weighted average median filter has applied to improve the image details precisely. Consider a variable q which represents the normalized grey levels in the image shown in Figure 3.

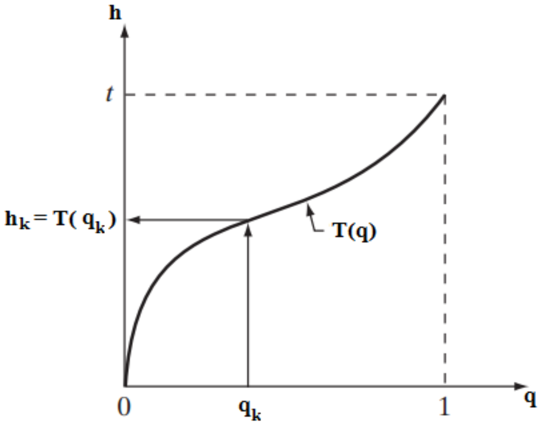


Fig-3: Histogram equalization transformation function [7]

Then histogram equalization transformation function has applied.

$$h = T(q) = \int_0^q p_q(z)\,dz,\ 0 \le q \le 1$$

The probability density function of q and h are given below [7]

$$p_q[q, q + dq] \cong p_q(q)dq \ \&\ p_h[h, h + dh] \cong p_h(h)dh$$

$$p_q(q)dq^{q=T^{-1}(h)} = p_h(h)dh \Rightarrow p_q(q) = p_h(h)\left.\frac{dq}{dh}\right|_{q=T^{-1}(h)}$$

$$\frac{dq}{dh} = \frac{dT(q)}{dq} = \frac{d}{dq}\left[\int_0^q p_q(z)dz\right] = p_q(q)$$

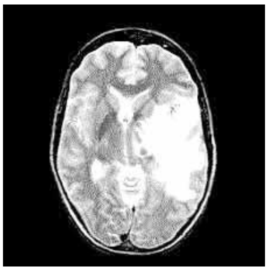
$$\frac{dh}{dq} = p_q(q) \Rightarrow p_h(h) = \left[p_q(q)\frac{1}{p_q(q)}\right]_{q=T^{-1}(h)} = 1, 0 \le h \le 1$$

Due to histogram equalization effect, edges which are characterized by sharp intensity transition have blurred. Then weighted average filter has applied to reduce the blurring effect of edges of the MRI images. The mask of the weighted average filter has defined as given below

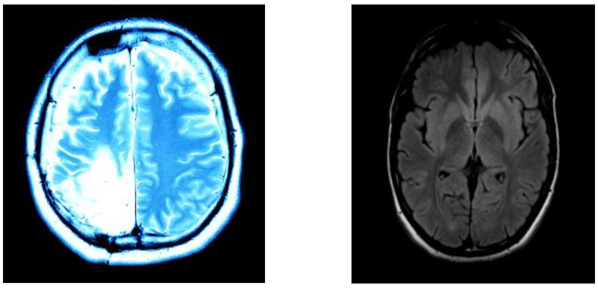
$$\frac{1}{16} \times \begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}$$

Mathematically, the mask of the image $\Omega(x, y)$ can be defined by the following expression [7]

$$m(x, y) = \frac{\sum_{h=-a}^{a}\sum_{t=-b}^{b} z(h, t)\Omega(x + h, y + t)}{\sum_{h=-a}^{a}\sum_{t=-b}^{b} z(h, t)}$$


(a) Type-1


(b) Type-2



(c) Type-3 (d) Type-4

Fig-4: Noise has removed using histogram equalization and weighted average filter

C. Image enhancement

No clearly visible contrast have present between the brain and tumor area. Contrast stretching and unsharp masking and high boost filtering have performed to enhance with clearly visible characteristics of the MRI images. To increase the contrast of specific region of the MRI images, grey level slicing has used for contrast stretching shown in figure 5.

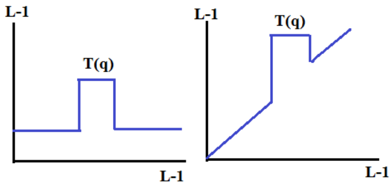


Fig-5: Grey level slicing of contrast stretching

The increase of contrast has improved the high density area of brain and probable tumor region. Then unsharp mask and high boost filtering effect have applied to improve the boundary edge quality of the images. The whole process can be defined by the flow chart given in figure 6.

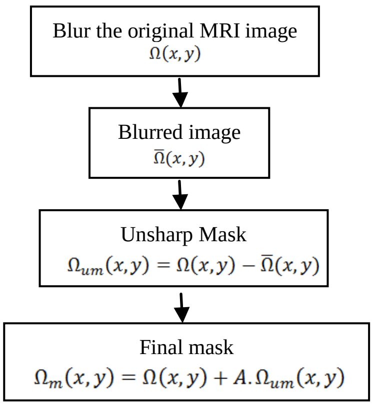


Fig-6: Unsharp masking and High boost filtering process

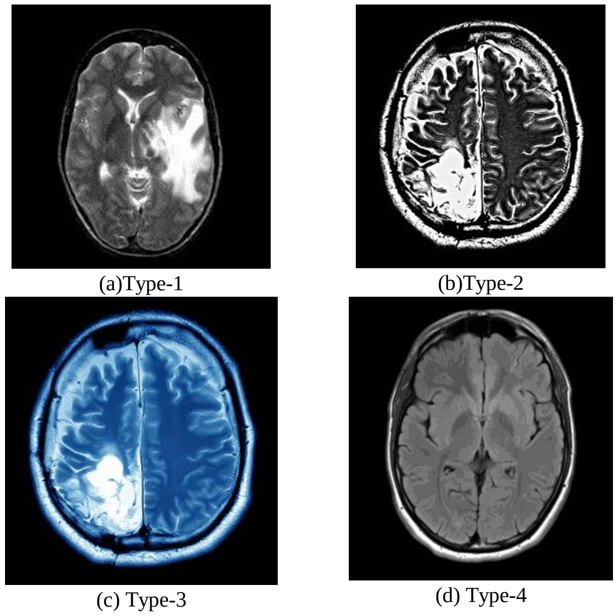
Here, A is the weight. For $A=1$: Unsharp mask, $A>1$: High boost filtering, $A<1$: De-emphasize the contribution of the mask. The high boost filtering mask can be defined as [7]

$$\Omega_{HighBoost}(x,y) = A\Omega(x,y) - \nabla^2\Omega(x,y)$$

Where, ∇^2 is the Laplacian operator.

$$\nabla^2\Omega = \frac{\partial^2\Omega}{\partial x^2} + \frac{\partial^2\Omega}{\partial y^2}$$

The laplacian operator or second derivative improves the details much better than the first derivative which is suitable for sharpening the images.



(a)Type-1 (b)Type-2

(c) Type-3 (d) Type-4

Fig-7: Improved MRI images after image enhancement

D. Image Segmentation

To locate objects and boundaries such as lines or curves, segmentation performs separation of MRI image depending on colour or texture into several parts which makes further processing simpler. Rejoining the several parts constitute the entire MRI image. In this process, region splitting, merging and growing based segmentation methods have performed to determine the desired tumor region directly. In region splitting mechanism, the whole image has broken into set of disjoint regions.

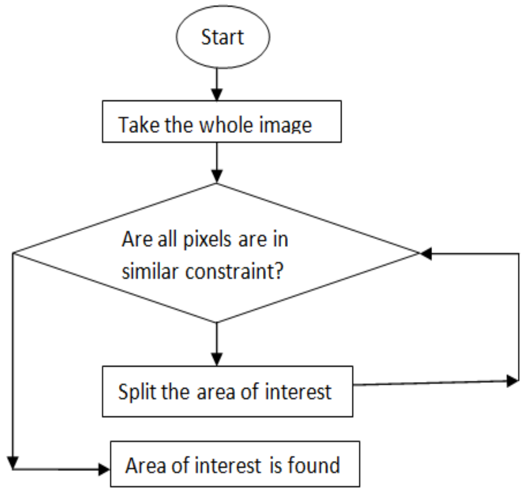
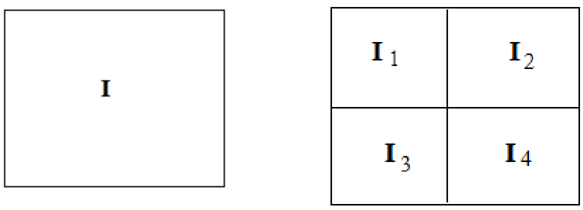
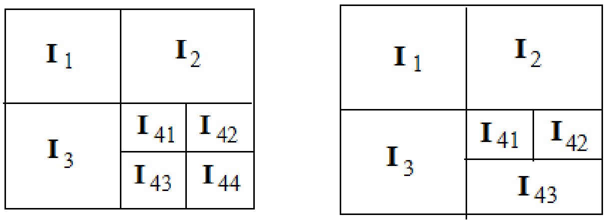


Fig-8: Region splitting based segmentation process



(a) Whole image (b) First split



(c) Second split (d)Merge

Fig-9: Region splitting approach

When all pixels in I are similar, then consider the whole image as interest region or area shown in figure. If all pixels are not similar, then the whole image has split into four regions I_1, I_2, I_3 and I_4. When all pixels are similar except I_4 regions, then the I_4 region has split further into four regions shown in figure 9. If the regions of I_{43} and I_{44} are found as identical, then these two regions have merged together shown in figure 9.

Region growing is the opposite of the splitting and merging approach shown in figure 10. When a seed pixel which does not belong to any area or region, then region growing process has stopped and another seed pixel has chosen until all pixels belong to some area or region. Thus a tumor cell and normal cell of brain can be identified.

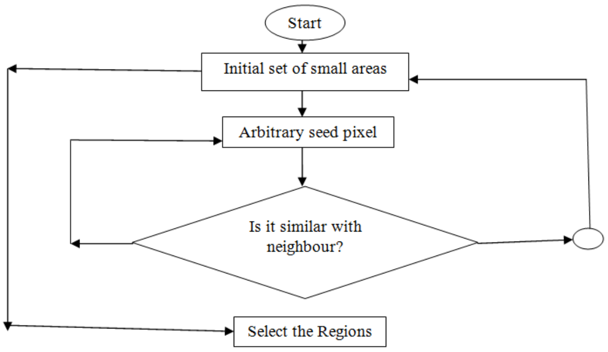
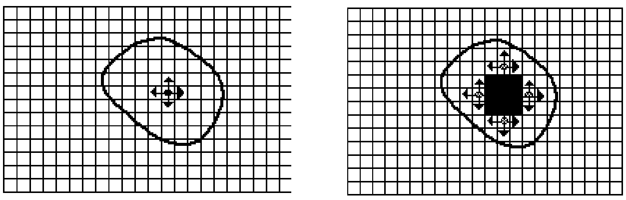


Fig-10: Image segmentation region growing approach



(a) Region growing process starts with initial seed pixel

(b) After few iterations, region growing has increased

Fig-11: Brain tumor detection technique based on region growing approach

E. Feature extraction and classification

To separate the tumor part of the MRI image, morphological operation has applied on the binary converted image. Pixel has non-zero value when the test is successful and as a result only the tumor portion has become visible. Then the tumor portion has marked to classify or highlight the tumor region in the MRI image.

III. RESULT & DISCUSSION

In this section, the experimental results of this work are described. At first graphical user interface (GUI) has created for making user friendly application shown in figure 12. GUI has two segments such as input MRI image and detected tumor.

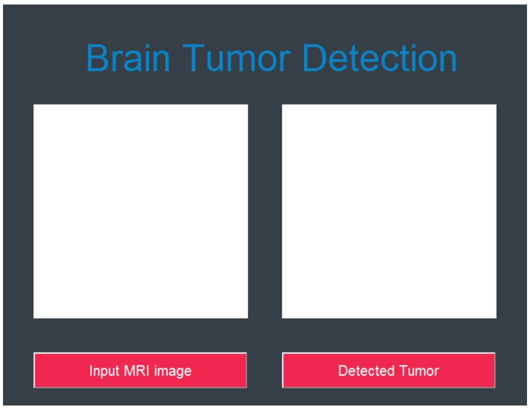


Fig-12: GUI for brain tumor detection

When a user clicks the input MRI image button, then they can select their MRI image and after that by clicking detected tumor button, the region splitting, merging and growing based segmentation process will be performed and the desired tumor region will be visible.

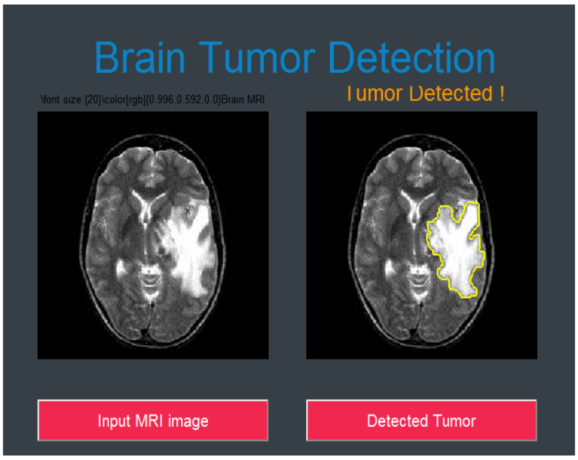


Fig-13: Brain MRI with tumor type-1

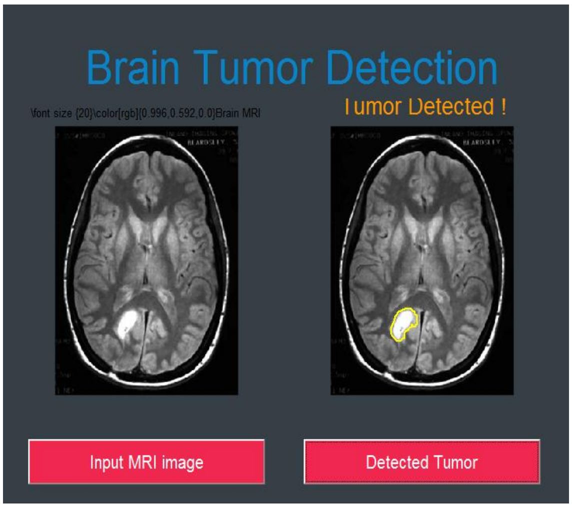


Fig-14: Brain MRI with tumor type-2

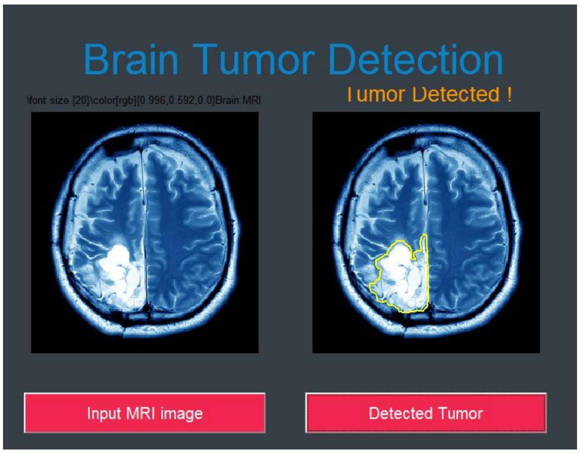


Fig-15: Brain MRI with tumor type-3

Brain tumor detection has performed using MATLAB program. Figures shown in from 13 to 15, three different MRI images with different types and sizes of tumor have checked to identify the tumor regions automatically within a very short time. In figure 16, as there has no tumor cells, no tumor has detected.

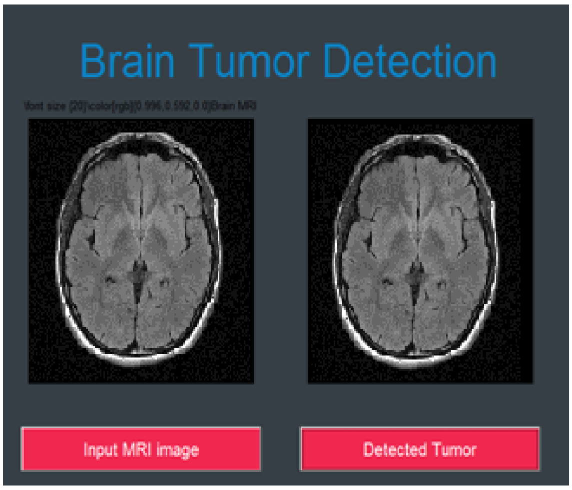


Fig-16: Brain MRI with no tumor detection

Total 136 MRI images have checked including pre-stage, mid-stage, last-stage and images with no tumor. The performance of this process has measured by evaluating the accuracy of the mechanism shown in table I.

Table-I: Performance evaluation of the proposed model

Type of MRI images	Pre-stage tumor	Mid-stage tumor	Last-stage tumor	No tumor
Number of MRI Images	35	46	55	44
False detection	1	1	0	1
No detection with tumor	1	0	0	-
Correct detection	33	45	55	43
Accuracy (%)	94.28%	97.82%	100%	97.72%

IV. CONCLUSION

Image processing has important application in biomedical field. This paper proposed a methodology to detect a tumor quickly from MRI images. After removing noise and enhancing image quality, the MRI image was subjected to region splitting, merging and growing based segmentation process which identified the region of brain tumor. This methodology can be applied in detecting brain tumor within a short period automatically with generated MRI images from MRI machines. Histogram equalization, weighted average filter, contrast stretching and unsharp mask high boost filtering processes have done to ameliorate the image quality for further processing. After that image segmentation process based on region splitting, merging and growing approach have performed to extract the tumor features and then label the region where the tumor has found. The developed method has achieved nearly about 100% accuracy in case of mid and last stage tumor detection. In future, more projects including correlation and neural network can be added by which pre-stage tumor can be identified with 100% accuracy based on this proposed methodology.

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