ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

BRAIN TUMOR DETECTION IN MRI USING MORPHOLOGICAL OPERATIONS BASED IMAGE SEGMENTATION

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DOI: 10.5281/zenodo.49193

ABSTRACT

Brain is the most important part in the human body. It is also the most significant element of CNS (Central Nervous System). The brain tumor is the abnormal growth which is caused by cells that grows in uncontrolled manner inside the skull. There are many factors that determine how the brain tumor effects the normal functioning of human body. Among these factors, the location of tumor is one of the most important factors. Thus, the detection of tumor is main objective of the system. It plays a vital role in biomedical system. For the detection of tumor, image processing particularly image segmentation is used. CT (Computed Tomography) scan and MRI (Magnetic Resonance Imaging) are two methods used for imaging of brain tumor. In this paper, MRI brain image is used for the process of tumor detection. This system involves test the brain image process, image filtering, skull stripping, segmentation, morphological operations, and calculation of tumor area and detection of tumor location. The detailed procedures are implemented using MATLAB. MRI gives exact location of tumor and it proves very helpful for doctors for further diagnosis and surgery.

KEYWORDS: Detection, Magnetic Resonance Imaging, segmentation, skull stripping, morphological operations.

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INTRODUCTION

Human body is composed of many cells. Each cell has its own function. These cells grow and divide for the formation of a new cell of same kind. When these cells grow abnormally or in an uncontrollable way, this process gives rise to a mass of unwanted tissues resulting in tumor. Brain tumor is also an abnormal growth of cells but particularly inside the skull. The tumor will grow from cells of brain, nerves that emerges from brain and brain tissues. As all parts of the body are controlled by brain cells, so brain is a vital organ of body. Brain tumor is a very serious disease in children and adults these days. Brain Tumor spreads very quickly. Due to its location and quickly spreading nature, it is difficult to treat.

There are basically three kinds of tumor:

1. Benign
2. Pre Malignant
3. Malignant Tumor

Benign tumors do not affect other healthy tissues of brain. The second one is the pre-cancerous stage. But if it is not treated properly, it may lead to cancer. Malignant tumor is the most dangerous one because it grows rapidly and ultimately leads to death of patient.

METHODOLOGY

The basic methodology used here is image segmentation. The digital image of brain is obtained from MRI scanning. Image segmentation is the process of partitioning a digital image into multiple segments. Image segmentation typically used to locate objects and boundaries i.e. lines and curves etc. The basic goal of image segmentation is to simplify the representation of image into something that is more meaningful and easier to analyze. The experiments have been implemented using MATLAB r 2013a.

Further following steps are involved in this process:

I. Preprocessing
II. Skull Stripping
III. Segmentation
IV. Morphological Operations
V. Calculation of tumor region

The detailed description of above steps is given is:

Preprocessing

Preprocessing is the primary step in image analysis. It involves the input MRI brain tumor image and image filtering. The MRI images are the images which can be obtained on computer when a patient is scanned by MRI machine. Generally, MRI images on computer are 'black and white' images.

Image filtering is mainly used to suppress either high frequencies in images i.e. smoothening the image or low frequencies i.e. enhancing or detecting edges in images. In this, several filters can be used but as far as the MRI image is concerned, it doesn't contain much noise. Thus, the average filer is used to smooth the image. Average filter is a low pass filter. It is a simple and easy method of smoothening images.

The operation of average filter is:

$g(x,y) = 1/M \sum_{(x,y)\epsilon S} f(x,y)$ (i)

Where,

S= neighborhood of pixels (x, y)

M= number of pixels in neighborhood

Skull Stripping

In biomedical image analysis, skull stripping is very important process. It is required in case of brain images only not in other medical image analysis such as lungs, heart etc. It is required to be done before other image processing steps. It is basically a process of eliminating all non-brain tissues from brain image i.e. to determine the boundaries of object which helps to find out the region of interest (ROI) i.e. the part of image containing tumor. There are various methods used for skull stripping using image contour, skull stripping based on histogram analysis, skull stripping based on region growing and mathematical morphology, skull stripping based on resonance principle and skull stripping based on threshold value. In the paper, skull stripping based on threshold value is used to remove skull tissues in which threshold value of skull tissues and normal brain tissues are determined for every image manually.

Segmentation

There are various types of segmentations but in this paper, Watershed segmentation is used which is a gradient based segmentation technique. Watershed segmentation solves various image segmentation problems. This technique uses gradient map of image as a relief map and segments image as a dam. This segmentation is done on the basis of intensity because every pixel has different intensity value as compared to each other. Watershed segmentation is suitable for images that have high intensity values. Marker controlled watershed segmentation is used to controlled over segmentation. For the edge detection Sobel operator is suitable. Sobel operator is used here to distinct the edges of object. The Sobel mask in matrix form is shown below:

$$M_x = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}, M_y = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 0 \\ -1 & 0 & 2 \end{bmatrix}$$

The equation of gradient magnitude which is used in Marker controlled watershed segmentation is

$$M=\sqrt{Mx^2 + My^2} \quad \text{(ii)}$$

Angle, $\theta=\tan^{-1}\frac{My}{Mx}$ (iii)

Morphological Operation

After segmentation, some morphological operations are performed for the separation of tumor region from the image. Morphological operation is a collection of non-linear operations which are related to the morphological features or shape of image. Morphological operations rely on the relative ordering of pixels. This technique probes an image with a small template which is called as structuring element. This structuring element is placed at all possible locations in the image and it is compared with the corresponding neighborhood of pixels. Some operations

test whether the element 'fits' within the neighborhood and some tests whether it 'hits' i.e. intersects the neighborhood.
A morphological operation on a binary image results in a new binary image in which the pixels have non-zero value only if the test is successful at that particular location in the image. The structuring element is a small binary image which means that it is a small matrix of pixels having a value of zero or one. There are various morphological operations but in this paper, erosion is applied to detect tumor.
The erosion of A by B is given by following expression:

$$A \ominus B = \{(i,j) : B_{(i,j)} \subset A\} \quad \text{(iv)}$$

Where A= the binary image
B= structuring element
(i,j) = center of pixel of structuring element

Calculation of tumor region

Finally, the area of tumor region is calculated by following equation:
Tumor area= A* total number of pixels in tumor region (v)
Also, A = V*H (vi)
Where,
A= area of each pixel
H= horizontal dimension of image
V= vertical dimension of image
H= 1/horizontal resolution of image
V= 1/vertical resolution of image

IMPLEMENTATION

The system is implemented as shown in fig. 1; which involves the use of input MRI image for the implementation of algorithm. First of all, the brain image is checked out to find out that whether it contains tumor or not. If the brain image contains tumor then steps are executed. The filter is used to remove noise from the image. The skull stripping is used for extraction of skull tissues. After that segmentation is performed where the brain image which is obtained after skull stripping, is segmented. After this, various regions or edges are detected using morphological operations. Then finally the tumor area is calculated. Now, in order to detect the location of tumor, tumor image which is obtained is divided into two parts. The right part is called left hemisphere and left part is called right hemisphere.
If the total number of pixels present in each part is equal, the tumor is located in the center of brain. Otherwise, two conditions are checked i.e. if the pixel value in left part of image is greater than that of right; the tumor is located in right hemisphere otherwise in left hemisphere.

RESULT AND DISCUSSION

The output images i.e. grayscale image, watershed segmented image are shown in following figures. Here, the real time patient data is used for analysis. Then the extracted tumor from MRI image for the given input is obtained. By using MRI, the tumor becomes easy to locate because it is having intensity value higher than background. The resultant images are shown as:

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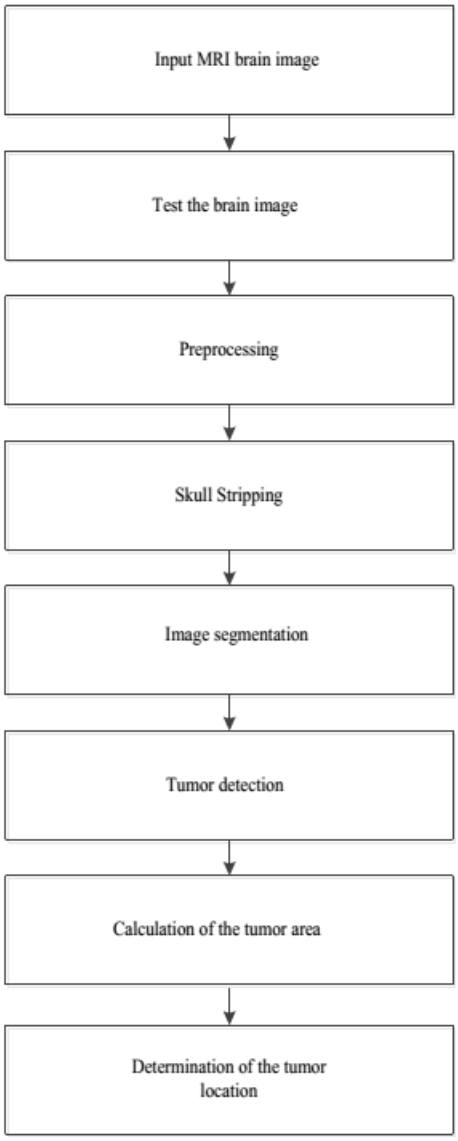
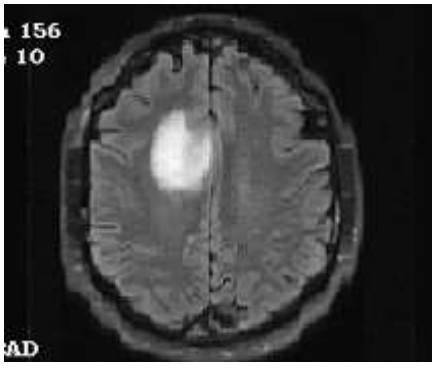
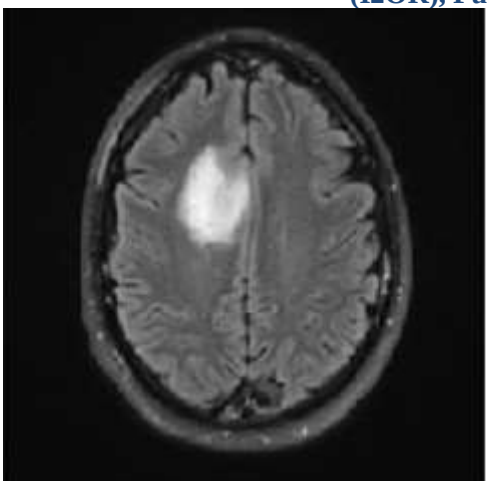


Fig.1. Implementation Procedure

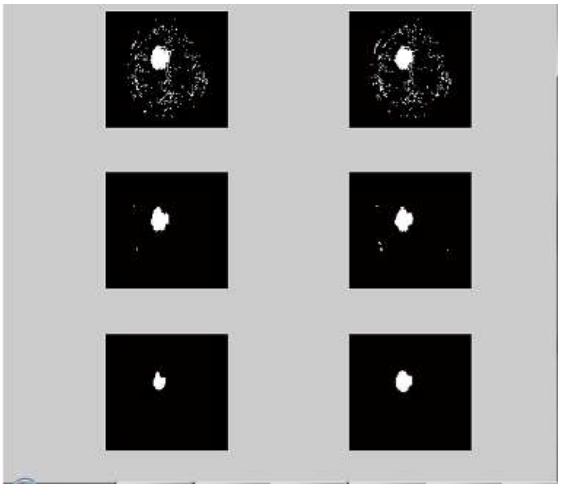


(a) MRI image of brain affected by tumor

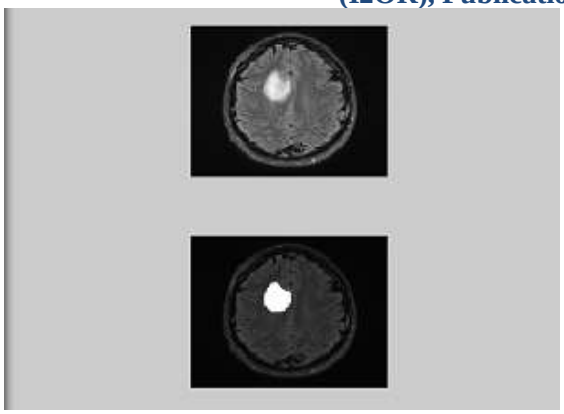


(b) Grayscale image of fig.(a)

(c) Watershed segmented image of input image



(d) Morphological operations



(e) Extracted tumor from MRI

CONCLUSION

In biomedical analysis, computer science plays a vital role for analyzing various diseases. MRI is a very important part in many researches. In this paper, the extracted or detection of tumor is considered based on skull stripping, watershed segmentation and morphological operation. This helps the doctors for further diagnosis and surgery.

FUTURE SCOPE

As the proposed work is applied only to grayscale images, the future work can be advanced for color images. Also the tumor can be classified according to its type.

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