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Efficient Image Segmentation based Brain Tumor Detection in MRI images

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Abstract— Major brain tumors are not diagnosed until after symptoms appear. Often a brain tumor is initially diagnosed by an internist or a neurologist. An internist is a doctor who specializes in treating adults. A neurologist is a doctor who specializes in problems with the brain and central nervous system. Diagnosing a brain tumor usually begins with magnetic resonance imaging (MRI). MRI Imaging play an important role in brain tumor for analysis, diagnosis and treatment planning. Brain tumor detections using MRI images are a challenging task, because the complex structure of the brain. Brain tumor is an abnormal growth of cell of brain. MRI images offer better difference concern of various soft tissues of human body. This paper has proposed Tumor Detection System to identify the abnormal growth of cells in brain. The methodology includes image pre-processing, image segmentation, morphological operations and the detection of tumor in the brain. The system was designed and developed using MATLAB.

Keywords—*medical imaging; Brain tumor; Magnetic Resonance Imaging; Thresholding; Histogram*

I. INTRODUCTION

Medical imaging refers to a number of techniques that can be used as non-invasive methods of looking inside the body. This means the body does not have to be opened up surgically for medical practitioners to look at various organs and areas. It can be used to assist diagnosis [24] or treatment of different medical conditions. Medical imaging technology has revolutionized health care over the past 30 years, allowing doctors to find disease earlier and improve patient outcomes. Imaging techniques use radiations that form part of the **electromagnetic spectrum [18].** Exploiting other types of radiation in the electromagnetic spectrum allows us to see further than our eyes allow us to using only visible light. The most familiar of these other types are x-rays, which are often used to show if a bone is broken. X-rays, however, are not very useful for looking at other tissues and the radiation can also be harmful to certain areas of the body [11]. Other techniques have been developed that allow different tissues and metabolic functions to be "seen" using different parts of the electromagnetic spectrum [4].

CT scans are a type of X-ray that creates a three-dimensional picture of the head by scanning the head from multiple different angles [10]. A computer combines these images into a detailed, cross-sectional view that shows abnormalities in the brain, or tumors. Diffusion Tensor Imaging (DTI) measures the flow of water through the white matter tracts of the brain [8]. This provides a snapshot of the brain's structure and can be used to compare changes over time.

Functional Magnetic Resonance Imaging (FMRI) scan is used to determine the specific location of the brain where a certain function, such as speech or motor function, occurs [23]. By pinpointing the exact location of the functional center in the brain, physicians can plan surgery or other treatments for a particular disorder of the brain [1].

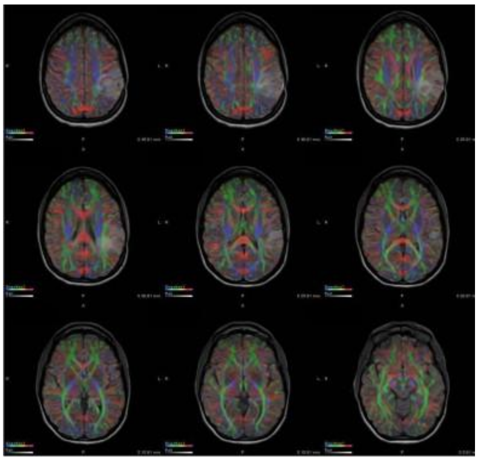

Fig.1 DTI of metastatic brain tumor

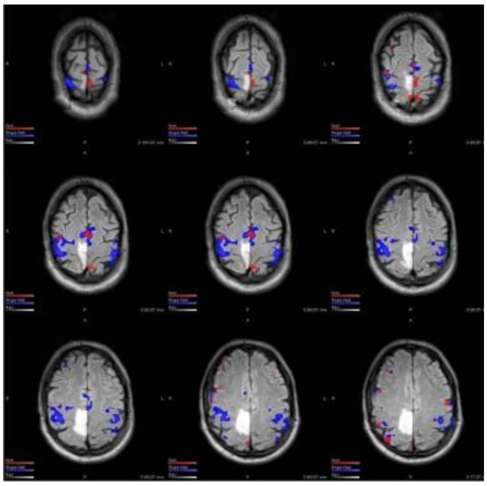

Fig. 2 FMRI of metastatic brain tumor

The best type of imaging to diagnose most types of brain tumours is Magnetic Resonance Imaging (MRI). These scans use magnetic fields and radio waves, rather than X-rays, and computers to create detailed pictures of the brain. MRIs show visual "slices" of the brain that can be combined to create a three-dimensional picture [15] of the tumour. Therefore, in this research we acquired MRI scan images of brain as the dataset to segment the tumour affected areas and interpret the results. As tumour in MRI image have an intensity more than that of its background so it become very easy locate it and extract it from a MRI image.

II. TYPES OF BRAIN TUMORS

Brain tumors can be classified into two general groups: primary and secondary.

A. Primary Brain Tumors

Tumors that originate within brain tissue are known as primary brain tumors. Primary brain tumors are classified by the type of tissue in which they arise. The most common brain tumors are gliomas, which begin in the glial (supportive) tissue. There are several types of gliomas, including the following:

- Astrocytomas arise from small, star-shaped cells called astrocytes [20]. They may grow anywhere in the brain or spinal cord. In adults, astrocytomas most often arise in the cerebrum. In children, they occur in the brain stem, the cerebrum, and the cerebellum. A grade III astrocytoma is sometimes called anaplastic astrocytoma. A grade IV astrocytoma is usually called glioblastoma multiforme.
- Oligodendrogliomas arise in the cells that produce myelin, the fatty covering that protects nerves. These tumors usually arise in the cerebrum [3]. They grow slowly and usually do not spread into surrounding brain tissue.
- Ependymomas usually develop in the lining of the ventricles. They may also occur in the spinal cord. Although these tumors can develop at any age, they are most common in childhood and adolescence.

There are other types of brain tumors that do not begin in glial tissue. Some of the most common are described below:

- Meningiomas grow from the meninges. They are usually benign. Because these tumors grow very slowly, the brain may be able to adjust to their presence. Meningiomas may grow quite large before they cause symptoms. They occur most often in women between 30 and 50 years of age [22].
- Schwannomas are benign tumors that arise from Schwann cells, which produce the myelin that protects peripheral nerves. Acoustic neuromas are a type of schwannoma. They occur mainly in adults. These tumors affect women twice as often as men.
- Craniopharyngiomas develop in the region of the pituitary gland near the hypothalamus. They are usually benign; however, they are sometimes considered malignant because they can press on or damage the hypothalamus and affect vital functions. These tumors occur most often in children and adolescents.
- Germ cell tumors arise from primitive (developing) sex cells, or germ cells. The most frequent type of germ cell tumor in the brain is a germinoma.
- Pineal region tumors occur in or around the pineal gland, a tiny organ near the center of the brain. The tumor can be slow growing (pineocytoma) or fast growing (pineoblastoma). The pineal region is very difficult to reach, and these tumors often cannot be removed.

B. Secondary Brain Tumors

Secondary brain tumors are tumors caused from cancer that originates in another part of the body. These tumors are not the same as primary brain tumors. The spread of cancer within the body is called *metastasis*. Cancer that spreads to the brain is the same disease and has the same name as the original (primary) cancer. For example, if lung cancer spreads to the brain, the disease is called metastatic lung cancer because the cells in the secondary tumor resemble abnormal lung cells, not abnormal brain cells. Treatment for secondary brain tumors depends on where the cancer started and the extent of the spread as well as other factors, including the patient's age general health, and response to previous treatment.

III. PROPOSED METHODOLOGY

The overall process of the proposed Thresholding based -Brain Tumor Detection System is displayed in fig.3. First, preprocessing [12] is done on the acquired images to understand the abnormal growth of a tumour in the brain. Histogram processing helps in identifying a normal brain and a tumour affected brain. Once identified with tumour to further detail the interpretation and segment the tumour, enhance the image by noise filtering. The filtering used here is median filter, after which thresholding is done to segment the tumour from other parts of the brain. Image thresholding is a simple, yet effective, way of partitioning an image into a foreground and background. This image analysis technique is a type of image segmentation that isolates objects by converting grayscale images into binary images [13]. Image thresholding is most effective in images with high levels of contrast [21]. Pseudo coloring helps to superimpose a pseudo-color label matrix on top of the original intensity image. This visualization illustrates how the locations of the foreground and background markers affect the result. In a couple of locations, partially occluded darker objects were merged with their brighter neighbour objects because the occluded objects did not have foreground markers.

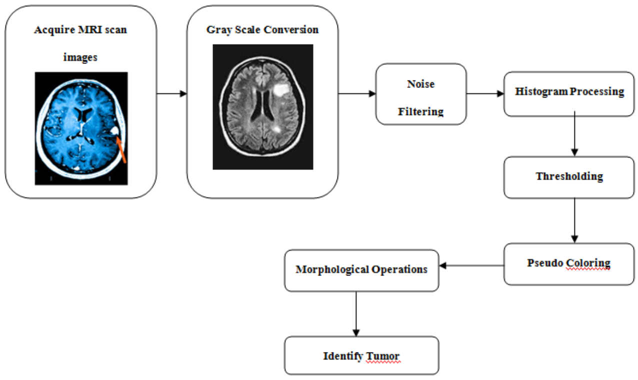

Fig. 3 The proposed – Thresholding based Brain Tumor Detection System

III. Experiments and Results

The proposed Tumour Detection System works as:

1. Acquire MRI scan images of brain and convert it to a gray scale image
2. Apply median filter to enhance the quality of image.
3. Histogram of the input image is processed.
4. Compute threshold value for image segmentation.
5. Pseudo coloring is done to illustrate the highlight markers affecting the result.
6. Morphological operations are done
7. Identify tumor and interpret for further investigation.

The system was designed and implemented using MATLAB R2014a.

A. Convert to Gray Scale Image

rgb2gray()- converts the truecolor image RGB to the grayscale intensity image. rgb2gray converts RGB images to grayscale by eliminating the hue and saturation information while retaining the luminance [19].

Fig. 4 Gray Scale Conversion

B. *Noise Removal*

Median filter is a non-linear filtering technique used to remove salt and pepper noise from the converted gray scale image [19]. It replaces the value of the center pixel with the median of the intensity values in the neighborhood of that pixel. Median filter is more effective than convolution when the goal is to simultaneously reduce noise and preserve edges [17]. medfilt2(A) performs median filtering of the matrix A using the default 3-by-3 neighborhood.

Fig. 5 Noise Removal

C. *Histogram Processing*

An image histogram is a type of histogram that acts as a graphical representation of the tonal distribution in a digital image [7]. It plots the number of pixels for each tonal value. By looking at the histogram for a specific image a viewer will be able to judge the entire tonal distribution at a glance. For this system we have used the comparison between two MRI scan images, one of a normal brain and the other of a tumor affected brain image. The output clearly shows the variation between two images, where a tumor growth in an image has one of the color intensity continuously high. This can initially identify an abnormality in a scanned image.

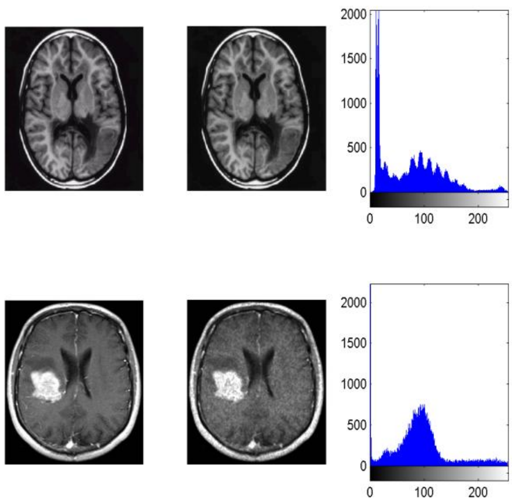

Fig. 6 Histogram shows the difference between normal and tumor affected brain.

D. *Thresholding*

Threshold is one of the widely methods used for image segmentation. It is useful in discriminating foreground from the background. By selecting an adequate threshold value T, the gray level image can be converted to binary image. The binary image should contain all of the essential information about the position and shape of the objects of interest (foreground).

If g(x, y) is a threshold version of f(x, y) at some global threshold T it can be defined as [4],

$$g(x, y) = 1 \text{ if } f(x, y) \geq T = 0 \text{ otherwise}$$

Thresholding operation is defined as:

$$T = M\,[x, y, p(x, y), f\,(x, y)]$$

In this equation, T stands for the threshold; f (x, y) is the gray value of point (x, y) and p(x, y) denotes some local property of the point such as the average gray value of the neighborhood centered on point (x, y). Thresholding techniques can be categorized into two classes: global threshold and local (adaptive) threshold [2]. In the global threshold, a single threshold value is used in the whole image. In the local threshold, a threshold value is assigned to each pixel to determine whether it belongs to the foreground or the background pixel using local information around the pixel.

a. Global thresholding: When T depends only on f (x, y), only on gray-level values and the value of T solely relates to the character of pixels [14], this thresholding technique is called global thresholding.

b. Local thresholding: If threshold T depends on f(x, y) and p(x, y), this thresholding is called local thresholding. This method divides an original image into several sub regions [6], and chooses various thresholds T for each sub region reasonably [7].

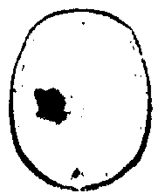

Fig. 7 Thresholding

E. *Pseudo Coloring*

Pseudo coloring can make some details more visible, as the perceived difference in color space is bigger than between successive gray levels alone. Pseudo-color processing is a technique that maps each of the grey levels of a black and white image into an assigned color [16]. This colored image, when displayed, can make the identification of certain features easier for the observer. The mappings are computationally simple and fast. This makes pseudo-color an attractive technique for use on digital image processing systems that are designed to be used in the interactive mode.

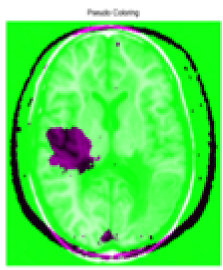

Fig. 8 Pseudo Coloring

F. Morphological Operations

Morphological operations apply a structuring element to an input image, creating an output image of the same size. In a morphological operation, the value of each pixel in the output image is based on a comparison of the corresponding pixel in the input image with its neighbours [9]. By choosing the size and shape of the neighborhood, we construct a morphological operation that is sensitive to specific shapes in the input image.

The most basic morphological operations are dilation and erosion. Dilation adds pixels to the boundaries of objects in an image, while erosion removes pixels on object boundaries [5]. The number of pixels added or removed from the objects in an image depends on the size and shape of the *structuring element* used to process the image. In the morphological dilation and erosion operations, the state of any given pixel in the output image is determined by applying a rule to the corresponding pixel and its neighbors in the input image.

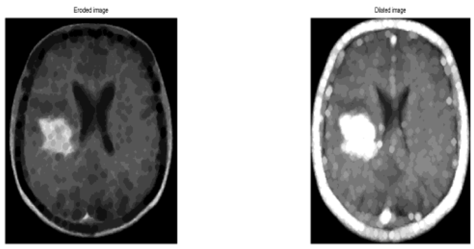

Fig. 9 Morphological Operations

G. Tumor Identification

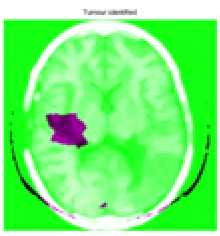

Fig. 10 Tumor Identified for further study

CONCLUSION AND FUTURE WORK

An MRI uses magnetic fields, not x-rays, to produce detailed images of the body. MRI can also be used to measure the tumor's size. MRIs create more detailed pictures than CT scans and are the preferred way to diagnose a brain tumor. Therefore we have used MRI images of brain for our research, which proved to be successful in identifying the tumor. This system may classify the type of tumor. Also tumor growth can be analyzed by plotting graph which can be obtained by studying sequential images of tumor affected patient.

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