A study of image processing approach for Brain Tumor Detection

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Abstract - The aim of this study is to It is now possible to derive precise anatomical features of the brain from clinical information utilising MRI or CT scans, which have revolutionised the medical imaging sector (CT). Beyond these procedures, PET makes use of noninvasive techniques to glean useful details regarding a patient's health and function. Additionally, it aids in the planning of surgeries, radiation treatments and the navigation of intraoperative procedures. The use of radiotherapy as an example illustrates this point, as it delivers a precise dose of radiation to the tumour while minimising collateral harm to healthy muscle. Imaging processes are designed to provide evidence regarding a specific location in the image. The tissue is penetrated by the X-ray CT by the application of photon attenuation. When using MRI, it is possible to figure out how dense water really is. The subject's anatomy can be seen clearly in MRI and CT scan images, and the varying density of tissues in different parts of the body can be identified in this way. Medical imaging poses a particularly complex set of issues when attempting to make sense of the data because of the large variety of individual variances. Another important factor when performing medical image processing is the presence of noise due to noise measurement, modality artefacts, and fluctuations in the intrinsic intensity of the region of interest. As a result, medical image processing employs a variety of techniques to eliminate noise and enhance images in the most effective way possible. The type of noise and its intensity are critical considerations because there are so many different imaging systems that rely on a wide range of measurement instruments. In addition, noise effects may vary greatly in different regions of interest, creating in further difficulties in their discernment, which often computes variance across intensity values rather than intensity values.

Keywords - Image Processing, Brain Tumor Detection, medical imaging sector, MRI and CT scan images–

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INTRODUCTION

It is estimated that in 2018, brain tumours were India's 10th most prevalent cancer type, according to the United News of India report [UNI 2018]. In India, there have been 28,142 new cases of brain tumours, resulting in 24,003 deaths. A benign or malignant brain tumour is a lump or mass in the brain that is abnormal. Malignant tumours are those that grow quickly, are cancerous, and spread rapidly. Tumors in the brain can take on a wide variety of shapes, sizes, locations, and appearances, making it difficult to conduct an accurate examination. In order to diagnose brain cancers in an early stage, there is a shortage of accurate measurement tools. However, if it is discovered early on, the appropriate therapy can be given, potentially lengthening the victim's life. All of the body's main processes are controlled by the brain, which makes it the most complex part of the body. It is protected by the skull because it is the most important part of the neurological system. Figure 1 [Louis et al. 2007] [2] depicts the brain's three main components: grey matter, white matter, and cerebrospinal fluid (CSF). In addition to covering the spinal cord, CSF provides numerous benefits to the brain's central nervous system.

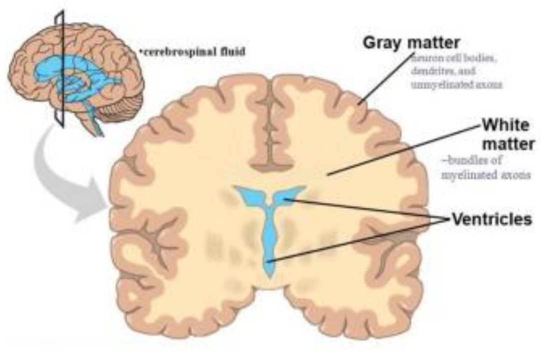


Figure 1: Brain Structure

Shocks are deflected by the CSF, which is rich in glucose, ions, and oxygen, all of which are dispersed throughout the neurological system. [3]. Waste materials from the nervous system are carried away by CSF.

Major parts of brain are:

- **Cerebrum:** Logic, reasoning, and creativity are some of the functions that are controlled by this portion of the brain. You can divide your brain into two parts: one half controls the body's left side and one half is responsible for the body's right. Subdivisions exist within each hemisphere, such as the "frontal lobe," "temporal lobe," "parahilaral," and "occipital" lobe." Cerebral thinking and memory storage occur in the cerebrum.
- **Frontal Lobe:** This portion of the brain helps in planning, organizing and problem solving. It controls behavior, personality and emotions of a person.
- **Occipital Lobe:** It is the region which lies in the back of the brain and processes visual information. It helps in visual recognition of different shapes and colors and finds association between them. Any damage to this lobe can cause failure of visual capability.
- **Cerebellum:** This is situated behind and below the cerebrum. Its main purpose is to maintain muscle coordination. If any problem occurs in this area, person can have problem in walking, talking and eating.
- **Brain Stem:** Brain is connected with spinal cord with the help of brain stem. This is very useful in controlling our body functions: “heart rate, digestion, breathing, blood pressure, and alertness”.
- **Temporal Lobe:** There are two types of temporal lobes: Left lobe and Right Lobe. Left lobe maintains verbal memory e.g. words and names. Right lobe maintains visual memory e.g. pictures and faces.
- **Parietal Lobe:** It helps in judgment of texture, weight, shape and size

ABOUT BRAIN TUMOR AND DETECTION METHODS

Tumors in the brain are caused by the uncontrolled proliferation of healthy cells. According to the American Cancer Society, 21,000 Americans are diagnosed with a brain tumour each year [Brain Tumor 2016]. [4]. There are almost 100 trillion cells in our body. Generally, cells divide, grow, and then die off in a recursive cycle. A child's growth is aided by the fact that cells divide at a quicker rate in young people. Cells begin to stop forming beyond a certain age. The cells are instead divided to replace dead cells or to repair any damage. New cells are constantly created and the old ones do not die when this process is interrupted. In one area of the body, the number of cells grows. This uncontrolled growth of cells is known as tumor

1 Brain Tumor Detection

Methods Brain imaging techniques help radiologists and researchers to detect problems in the human brain, without need of neurosurgery. There are a number of techniques available in hospitals all over the world which have been proved to be safe [5].

(A) CT Scan: Computed Tomography (CT) is used to construct brain images through a series of X-ray scans. In CT scan, the patient lies on a table which can slide in to center of CT scanner. Machine X-ray beam rotates around the patient. Scan usually only takes 30 minutes. It shows structural view of brain not the functional view.

(B) PET Scan: A Positron Emission Tomography (PET) scan is used to get functional view of brain. A small amount of radioactive material is injected in the body and scanner detects material when this material breaks down. A PET scan is able to show how different areas of the brain behave while doing various tasks. PET is able to detect following brain abnormality such as tumors, memory disorders and seizures

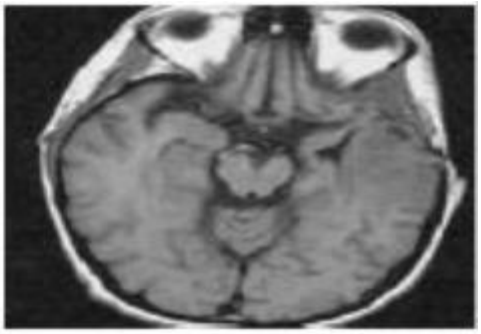
(C) MRI Scan: In the last few years, the uses of Magnetic Resonance Imaging (MRI) scanners in medical field have grown superbly [6]. Doctors use MRI scans in diagnosing brain tumor and cancer. An MRI scan is an efficient way to look inside the human body without the need to open it. An electric current is passed through wired loops, which is used to create strong magnetic field. Magnets in other coils are used to send and receive radio waves. After excitation of molecules, energy is released. This is picked up by coil and then sent to a computer for final processing.

2 MRI Modalities

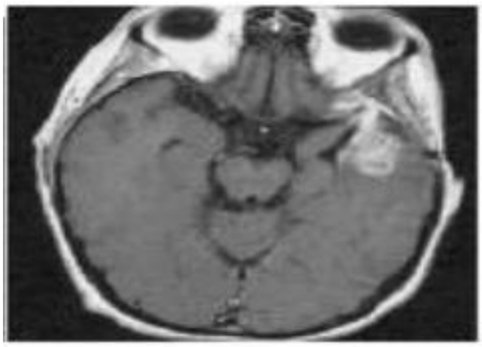
Tissue appearance can be affected by variable behavior of protons shown in different tissues. The speed at which mobile hydrogen protons are moving becomes helpful in determining amount of signal produced by specific tissue [7]. Basically, images are of three types:

- T1-Weighted
- T2-Weighted
- Fluid Attenuated Inversion Recovery (FLAIR) images
- T1-Weighted: These types of images have short Repetition Time (TR) and short Echo Time (TE). These images are grey scale images in which dark gray is used to show gray matter, lighter gray for white matter and black is used to show CSF. T1-

weighted image is shown in Figure 1.3 (a) and (b).



(a)



(b)

Figure 1 (a) T1-weighted image without enhancement(b) T1-weighted image with enhancement

T1-weighted images have following characteristics:

- Dark color is used to show CSF, bone and air
- Lighter gray is used to show fat and white matter
- Contrast among neocortex and WM is good
- Contrast among gray matter and white matter is fine
- More sensitive to water content
- White matter disease appears dark in lighter gray WM
- T2-Weighted: These types of images show good contrast among CSF, brain tissue, Gray matter and White matter.

T2-weighted images have following characteristics:

- CSF shown with lighter gray whereas air as dark black
- Fat like lipids shown with dark black
- White matter disease is shown with lighter gray
- Long TR and long TE

T2-weighted images are shown in Figure 3

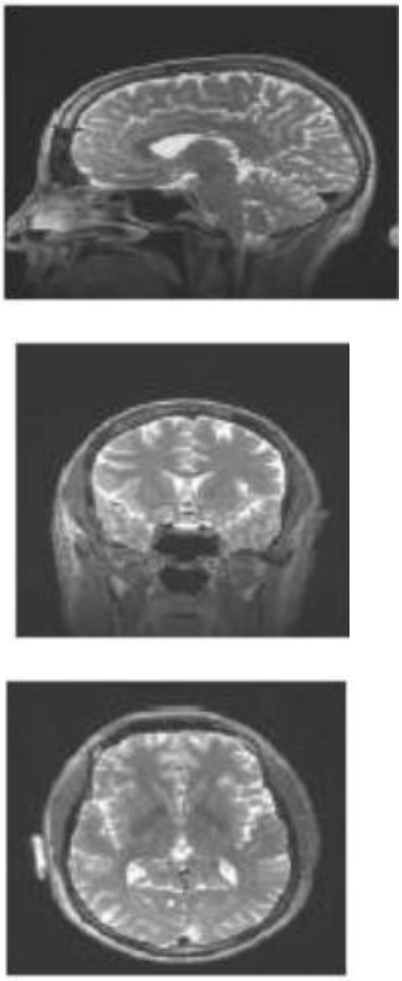
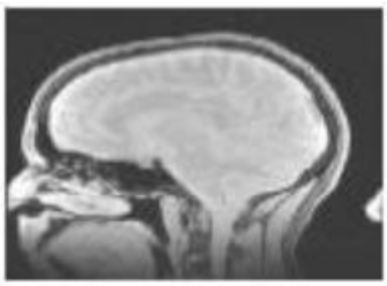


Figure 2: T2-Weighted Images

- FLAIR Images: These types of images (Figure 4) show good contrast between GM, WM and CSF. These provide good contrast between gray (bright) and white (darker gray) matter with little contrast between brain and CSF. The sample image with T1 Weighted, FLAIR and T2-Weighted images shown in the figure 4

FLAIR images have following characteristics:

- FLAIR images have long TR and short TE
- GM with lighter gray, WM with darker gray, CSF with black matter
- Air appears as dark and fats, lipids with lighter gray



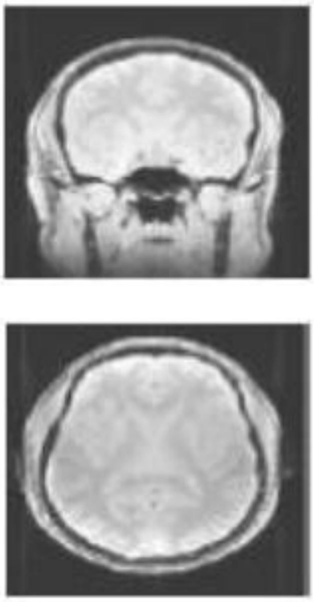


Figure 4: FLAIR Images

OVERVIEW OF IMAGE PROCESSING

An image's noise and abnormalities can be removed using a digital computer, which is the simplest description of image processing. When a picture is being created or transformed, noise and other irregularities might infiltrate it. As a two-dimensional function f(x,y) where x and y are spatial (plane) coordinates, the amplitude at any pair of coordinates (x, y) is called the intensity or grey level of the image at that location. We call a digital image if x, y, and f's intensity values are all finite, discrete quantities. A digital image must have a specific number of elements, each with a specific location and value. The terms "picture elements," "image elements," "pixels," and "voxels" all refer to the same thing. Digitized images are commonly referred to as "pixels" due to the widespread use of this term. There are five divisions in the picture processing. They practisevisualisation, which entails looking at things that aren't readily apparent. To achieve a higher-quality image, techniques such as image sharpening and restoration are used. Images can be retrieved via image retrieval. An image's various objects can be measured via pattern measurement. The goal of image recognition is to identify the various elements in a photograph. Digital Image Processing and Scene Analysis is the name given to the process of receiving and interpreting visual data on a digital computer. [Josefina Perlo et al, 2016] Digital Image Processing is a fast emerging discipline with growing applications in science and engineering. Developing a system that could execute the visual functions of all living organisms is possible with the help of Image Processing. Prior to the creation of such a machine are numerous theoretical and technological advancements. Many Image Processing applications for the benefit of humanity may be available in the near future, thanks to the current and predicted technology. In the 19th century, photography was first used to create images, and in the 20th century, television, X-rays, and electronic scanning were developed. In the 1950s, high-flying spies used spy planes to capture images of the Earth, and later, orbiting satellites used satellites to acquire pictures of the Earth's surface. When an image is processed, it is given a better appearance and is represented more efficiently than it was originally. Feature extraction, analysis, and recognition of images are all part of this field's scope, as are coding, filtering, re-sampling, and re-creation. The complete image processing and analysis process, from acquiring visual data to disseminating scene descriptions, it can be divided into three main stages which are also considered as major sub-areas which are given below:

- **Discretization and Representation:** Translating visual information into a discrete form suitable for computer processing, approximating visual information to save storage space as well as time requirement in subsequent processing.
- **Processing:** Improving image quality by filtering etc., reducing data to save storage space and channel capacity during transmission.
- **Analysis:** Extracting image features; quantifying shapes, registration and recognition.

IMPORTANCE OF IMAGE PROCESSING IN BRAIN TUMOR DETECTION

Image processing can be used in tumor detection. It has shown good efficiency in detecting cancer cells. Image preprocessing consist of two important steps they are

- Image Segmentation
- Image Enhancement

Image Segmentation is mainly to isolate the cancer cells from the background image and Image enhancement is to enhance the contrast between the cancer cells and the complete scan image of the brain.

1 Image Segmentation

Segmenting the image is the first stage. By dividing a picture into its constituent elements, objects, segmentation can be achieved. When an issue is being solved, the extent to which this subdivision is implemented will vary. This means that once the tumor's edge is spotted, the segmentation process should come to an end. Thus, the primary goal is to remove the tumour from its environment. To complicate matters even further, when scanning for cancer cells at their outer edges, the dark appearance of the fatty tissue creates a false positive. In order to overcome the problem, two steps are used:

i. Histogram equalization

ii. Thresholding

Histogram equalization has been applied to the image to increase the gray level near the edge. Thresholding is applied for the equalized image in order to obtain a binarized image with gray level 1 representing the cancer cells and gray level 0 representing the background.

2 Histogram Equalization

A picture's histogram shows the frequency with which various grey levels appear in the image. Changing the intensity of an image can be used to adjust the image's dynamic range and contrast. Modeling histograms with histogram modelling operators involves transfer functions that are non-linear and non-monotonic. It's possible to get a uniform distribution of intensities using histogram equalisation using a non-linear, monotonic mapping. A comparison of the original and histogram-equalized images is shown in Figure 1.6.

3 Thresholding

Separating out the areas of an image where objects are needed from the areas where backdrop is present is really helpful. If the foreground and background areas of an image have varying intensities or colours, thresholding is often an easy and effective approach to partition the image. Thresholding takes as input either a grayscale or colour image. Segmentation can be shown in a simple implementation as a binary image. The foreground is represented by white pixels and the background by black pixels. The intensity threshold is the only parameter that determines segmentation in a simple implementation. All pixels in the image are checked against this threshold in a single pass. If the pixel's intensity is greater than the threshold, it is converted to white in the output. If the value is below the predetermined threshold, the colour is set to black. Pixel-by-pixel, the image is segmented into individual objects or backgrounds, depending on the binary grey level of each one.

4 Image Enhancement

Contrast is the most important aspect of the image's improvement. On MRI, a contrast between the normal and malignant regions may be visible, but it is too faint to be noticed by humans. Consequently, a sharpening filter is used on the digital image, which results in a notable improvement in contrast between the normal and malignant regions.

BRAIN TUMOR DIAGNOSIS

The term "brain tumour" refers to an abnormal growth of cells in the brain's tissues (National Cancer Institute). Malignant (cancerous) tumours of the brain can be either benign or malignant (cancerous). When compared to healthy cells, cancerous cells develop as a result of unchecked cell proliferation and can spread to neighbouring tissues. In spite of the fact that benign tumours can grow large enough to put pressure on healthy organs and tissue, they rarely infiltrate other tissues. Metastatic brain tumours, or tumours that originate elsewhere in the body, are the second most common type of brain tumour. Depending on the size and location of the tumour in the brain and the processes that are regulated by that area of the brain, the symptoms of brain tumours might vary from person to person, from headache to stroke. An adult's first seizure, progressive loss of movement or sensation in arms or legs, unsteadiness or imbalance (especially if it is associated with headache), loss of vision in one or both eyes (especially if the vision is more peripheral), double vision (especially if it is associated with headache), hearing loss with or without dizziness, and gradual difficulty speaking are all symptoms listed by the National Brain Tumor Society. Vomiting, confusion and memory loss are also possible side effects. Noninvasive imaging methods, e.g. In the event that a brain tumour may be detected using an MRI, CT, or PET scan, unnecessary surgery would be avoided. Because of its higher soft tissue contrast and high-resolution information, MRI is an intriguing method for the anatomical characterization of brain malignancies. The method is still widely used in clinical practise, but it is unable to detect changes in metabolism. MRS and MRSI can provide valuable information on metabolism, as demonstrated by their ability to detect changes in metabolite concentrations.

CONCLUSION

When compared to tumors in other parts of the body, diagnosing a brain tumor is particularly difficult. It is one of the most frequent diseases in the world, defined by the unrestrained growth of abnormal brain cells. When paired with a well-established image processing technology, identification of this condition becomes significantly easier. The goal of this research is to devise a method for rapidly determining the size and location of tumors in MRI images by means of region splitting, merging, and segmentation depending on growth. An MRI picture is input into the system, which then undergoes preprocessing and augmentation, before the image is segmented and features are extracted. MRI contrast enhancement and median filtering have been utilized to enhance the image before a segmentation technique was used to detect a brain tumor after the picture has been collected. One of the primary goals of this study is to use medical picture segmentation to detect brain tumors in their earliest stages utilizing magnetic resonance imaging (MRI).

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