

Chapter 1

Introduction

1.1 Motivation

The human brain is indeed a non-transplantable organ that plays a crucial role in various bodily functions and cognitive processes. It consists of soft tissue and is protected by the skull. The brain is responsible for controlling essential functions like breathing, muscle movement, sensory perception (such as vision and hearing), memory, thinking, and personality.

However, when abnormal cell growth occurs in the brain, it can lead to the development of a brain tumor. A brain tumor is a mass or growth of cells that forms within the brain. These tumors can be either benign (non-cancerous) or malignant (cancerous). Brain tumors can disrupt the normal functioning of the brain by pressing on surrounding structures, interfering with neurological pathways, and affecting various cognitive and physical abilities.

The symptoms and effects of brain tumors can vary depending on their size, location, and rate of growth. Common symptoms may include headaches, seizures, changes in vision or hearing, difficulty with balance or coordination, cognitive impairment, mood changes, and personality alterations. Treatment options for brain tumors may involve surgical removal, radiation therapy, chemotherapy, or a combination of these approaches, depending on the specific characteristics of the tumor and the individual's overall health [73].

The worldwide base statistics [24] on brain tumors indicate an incidence rate of approximately 10.82 per 100,000 persons per year.

According to the article published in "The Hindu" on October 18, 2016, the annual number of brain tumor diagnoses in India is estimated to be between 40,000 and 50,000. Out of these cases, 20%

are children, which is a concerning increase compared to the previous year when the percentage of children affected was around 5%.

In 2018, brain tumors were ranked as the 10th most common type of tumor among Indians. According to the International Association of Cancer Registries (IARC), there were over 28,000 reported cases of brain tumors in India each year. Additionally, it was reported that more than 24,000 people die annually in India due to brain tumors[46].

Medical imaging plays a crucial role in the current treatment strategy for brain tumor diagnosis. Techniques such as CT (computed tomography), MRI (magnetic resonance imaging), and PET (positron emission tomography) scans are widely used in the imaging process.

MRI scans, in particular, are highly sensitive to external noise during the imaging process. Loud tapping, knocking, and other types of noise can interfere with the quality of the imaging data. This is because MRI scans rely on the detection of signals emitted by hydrogen atoms in the body, and external noise can disrupt these signals, leading to distorted images[101].

Brain tumors and their diagnosis and treatment require collective efforts from all segments of society. Researchers play a vital role in advancing our understanding of brain tumors, developing innovative treatment strategies, and improving diagnostic techniques. Their contributions are crucial for making progress in this field and ultimately improving patient outcomes. Being a responsible part of society, we researchers must take a vital role in this field.

1.2 Key underlying information

1.2.1 Brain and Brain Tumor

The human brain is a non-transplantable organ, which is made of 60% and 40% combination of water, protein, carbohydrates, and salts. In a scanned image, the brain can be categorized into two regions i.e., 'White matter(WM)', and 'Gray matter(GM)'. Gray Matter is composed of neuron cell bodies (somas), dendrites, glial cells, and synapses, whereas White matter is composed of axons.[127]. The following figure(Figure-1.1) shows the white matter and gray matter areas of the Human .

On the other hand, is nothing but the unbounded growth of cells within the brain. A tumor region may include active tumor cells, dead cells(necrotic), and a swelling area(edema)[114]. According to growth rate brain tumors can be broadly classified into two categories i.e., Benign (grows slowly

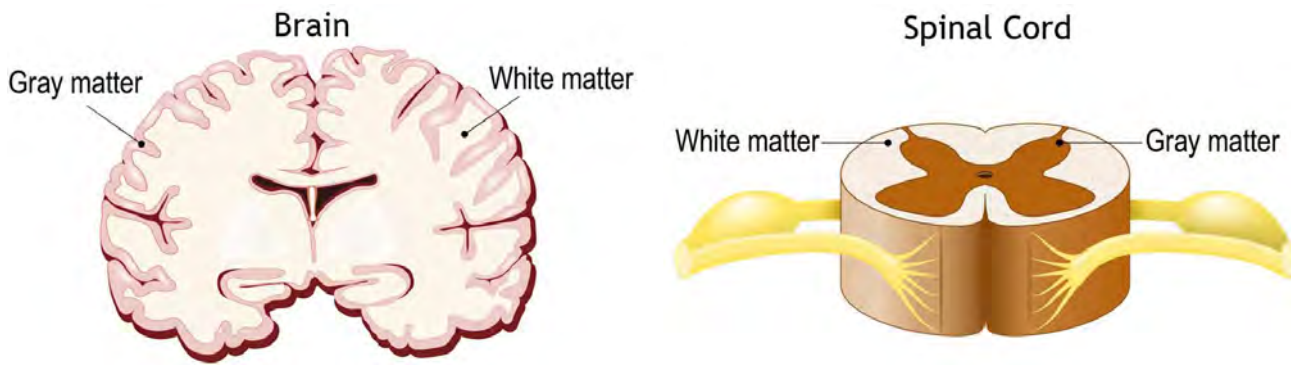


Figure 1.1: Brain anatomy: White matter and Gray matter[127]

Grade I	Slow-growing tumor, long-term survival, postoperative opportunity of heal after resection
Grade II	Comparatively slow growing, often recurs, sometimes tends to progress to higher grades of malignancy
Grade III	High proliferative potential, histologically malignant tumor, most patients receive adjuvant radiation and/or chemotherapy
Grade IV	Rapid proliferation, cytologically malignant tumor, very aggressive

Figure 1.2: WHO classification of brain tumor[62]

and doesn't spread in other body parts) and Malignant (grows rapidly and may spread in other body parts)[115]. Furthermore, the World Health Organization has classified brain tumors into four categories[62].

1.2.2 Diagnosing Brain Tumor with MRI

Over the decades has been the most popular imaging approach for diagnosing brain tumors, because of its high-resolution, high-precision, and low-noise feature. Moreover, MRI comes with different modalities to express different tissues with different contrast, such as T1, T2, FLAIR, etc. In T1 modality TE (Time to Echo) and TR (Repetition Time) times are kept short, whereas in T2 modality TE and TR times are kept long. FLAIR is similar to T2 imaging, the only difference is here CSF(cerebrospinal fluid) signal is suppressed while enhancing the contrast between gray matter, white matter, and tumor(if present)[95]. The following table(Table-1.1) describes the modality-wise color codes for different brain parts. Figure-1.3 shows the tumor imaging in various MRI modality images.

Table 1.1: MRI modality-wise color sequence of brain components[95]

Modality	Tissue				
	White Matter	Fat	Cortex	Inflammation	CSF
Flair	Dark Gray	Light	Light Gray	Bright	Dark
T1-Weighted	Light	Bright	Gray	Dark	Dark
T2-Weighted	Dark Gray	Light	Light Gray	Bright	Bright

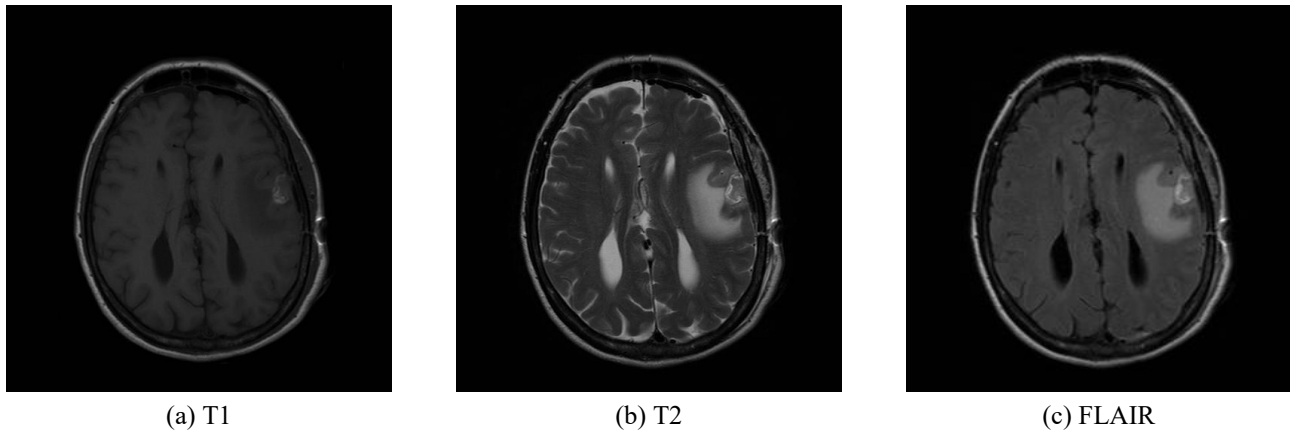


Figure 1.3: Brain tumor imaging in various MRI modalities

1.2.3 Diagnosing Brain Tumor with CT

Unlike MRI, a scan uses X-rays to create a detailed cross-sectional brain image. However, in CT scans, images are produced with low contrast compared to MRI. But, there are some advantages of CT over MRI, such as

- **Availability:** In most urban and semi-urban areas MRI facility is likely to be present but in rural areas MRI options are rare. Whereas, CT facilities are relatively better compared to MRI.
- **Cost and Time:** In the case of costing, CT is 2 to 3 times cheaper than MRI. Moreover, CT is much faster than MRI.
- **Special cases:** There may be some situations when patients cannot avail MRI, such as very overweight patients or patients having fears of enclosed spaces. For them, CT is the only diagnosing option.

1.3 Aim and Objectives

The Medical imaging technique has been developed in the last few decades, so far that now it is possible to view the whole interior part of the body. In the case of Brain Tumor diagnosis, the MRI

and CT imaging technique has played an important role. However, the MRI or CT images can be effectively read by a human expert only. The human expert used his knowledge gained throughout his career to identify the infected area. As the number of these human experts is very limited in society with respect to the number of affected persons, it is not always possible to serve all of them. For a 3rd world developing country, like India, the scenario is worse than other countries. For this reason, the workload on these human experts is very high, which may cause stress and may lead them to make some mistakes in their job. So it should be beneficial for the society and medical diagnosis field to have an automated system that can detect and extract the Tumor region from medical images if possible. Moreover, an automated system does not suffer from stress and there is no chance to commit any kind of mistake. To accomplish this purpose we need a GUI-based system, in which users will get the facility of uploading an MRI image. After that the user may check for the Tumor is present or not. If the system finds any abnormality then it will go into the segmentation phase and finally, it will generate a preliminary report for the input image



Figure 1.4: Plan of Work

1.4 Overview of Chapters

The remainder of this report is organized as follows:

Chapter-2 — introduces various pre-processing methodology, which includes Head Masking, Contrast enhancement, and skull stripping. All the proposed algorithms in this chapter are purely based on different Image-processing operations.

Chapter-3 — discuss the proposed techniques for tumor detection and segmentation approaches. An innovative Histogram-based feature has been proposed here for tumor detection. Moreover, a simple CNN network has been also proposed for CT tumor detection. For tumor segmentation, Super-pixel classification-based strategies are also proposed.

Chapter-4 —discuss and summarize the outcomes of the algorithms proposed across the chapters. Comparative analysis with the other state-of-the-art methods is also shown with respect to standardized metrics.

Chapter-5—briefly discusses the benefits, limitations, conclusion, and future scope of the work.