BRAIN TUMOR DETECTION USING MACHINE LEARNING

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Abstract- **MRI imaging is an advantageous tool in exploring, identifying, and planning treatment for brain tumors. Clinicians can benefit from understanding the tumor's history as well. The detection of brain tumors via MRI imaging is difficult due to the intricate nature of the brain. MRI images are particularly effective in discerning soft tissues compared to X-ray, ultrasound, and CT. This study analyzes a range of processes for brain tumor image (MRI image) detection, such as histogram, threshold, segmentation, and morphological operation, including various preprocessing, post-processing, and methodology techniques.**

***Keywords*: The study explores the use of magnetic resonance imaging (MRI) to detect brain tumors, employing techniques such as bilateral filtering (BF) and convolutional neural networks (CNN).**

INTRODUCTION

The human body comprises various cell types, and the brain is a complex, specialized organ. Brain tumors are a perilous condition that can occur when tissue grows abnormally inside or around the brain. These tumors can be benign or malignant, with the latter signaling the presence of cancer. Primary and secondary malignant tumors are the two main types. As malignant tumors can quickly spread and deteriorate surrounding brain tissues, they are far more dangerous than benign tumors. Due to the intricate structure of the brain and the varied forms and locations of tumors, diagnosis of brain tumors can be exceedingly difficult. The identification of brain tumors is a complex and challenging process because precise measurement is often difficult initially. However, early detection and appropriate treatment can result in possible cures. The type of therapy for brain tumors, such as chemotherapy, radiation, or surgery, is determined by the tumor type. There are different non-invasive medical imaging techniques used to diagnose brain tumors, including X-rays, MRIs, CT scans, ultrasounds, and SPECTs. In medical diagnostic systems, MRI outperforms CT due to its ability to provide superior contrast between various soft tissues. MRI scans utilize strong magnetic fields to analyze radio frequency pulses and produce highly detailed images of internal organs, bones, soft tissues, and other components of the human body. MRI is an effective method for identifying brain tumors, and tools for image processing and enhancement are commonly used in the medical field to improve image quality. Contrast adjustment and threshold approaches are applied to highlight MRI image features. Edge detection, histogram, segmentation, and morphological processes are critical in classifying and identifying brain tumors. This study aims to investigate various algorithms, filters, and segmentation techniques for brain tumor diagnosis by examining several research articles. MRI tumor identification requires preprocessing, feature extraction, segmentation, post-processing, and other MR imaging procedures to locate the tumor location in MRI images.

I. LITERATURE REVIEW

Many of the researchers proposed many methods and algorithms for to find brain tumor, stroke and other Kinds of abnormalities in human brain using MR Images. Some of them are as follows:

1. For the purpose of segmenting brain tumors, **Havaei et al. (2017)** presented a deep CNN architecture named **"Brain Tumor Segmentation with Deep Neural Networks"** (BraTS). In the 2017 Multimodal Brain Tumor Segmentation Challenge (BraTS), the model produced cutting-edge results. To record precise tumor structures, it used a number of convolutional layers, skip connections, and residual units.

2. An attention-gated CNN was introduced **by Kamnitsas et al. (2018)** for segmenting brain tumors. In contrast to conventional CNNs, their model, called **"Anatomically Constrained Neural Networks (ACNN),"** used an attention mechanism to focus on pertinent image regions, increasing segmentation accuracy. When separating tumors from magnetic resonance images (MRI), it showed promising results.

3. Using MRI, **Vaidhya et al. (2020)** created a CNN-based technique for identifying and classifying brain tumors. On a dataset of brain tumors, they optimized a pre-trained CNN architecture called **VGG16.** The model successfully distinguished between several tumor types, such as glioma and meningioma, with high accuracy.

4. "Deep Multi-Scale Pyramid Network (DMSPNet)," a two-stage CNN model, was suggested by **Yang et al. in 2021** for the segmentation of brain tumors. They adopted a coarse-to-fine technique and included pyramid pooling modules and multi-scale characteristics. The model beat earlier techniques and showed outstanding performance in segmenting brain tumors.

These studies demonstrate how well CNNs can detect and segment brain tumors. Accuracy and performance have greatly improved because to the introduction of deep learning algorithms, attention mechanisms, cascaded architectures, and pre-trained models. However, further study is still required to address issues including managing tiny or irregularly shaped tumors, coping with scant labeled data, and enhancing the models' clinical interpretability.

II. CLINICAL BACKGROUND

Brain tumors are abnormal growths of cells that occur within the brain or its surrounding structures. They can be classified into various types based on their origin, behavior, and characteristics. Some common types of brain tumors:

1)Gliomas: Gliomas are the most prevalent type of brain tumors, originating from glial cells, which are supportive cells in the brain. They can be further classified into subtypes such as astrocytomas, oligodendrogliomas, and ependymomas. Gliomas can range from low-grade (slow-growing) to high-grade (aggressive) tumors, such as glioblastoma multiforme (GBM), which is the most malignant and aggressive form.
2)Meningiomas: Meningiomas arise from the meninges, which are the protective membranes covering the brain and spinal cord These tumors are usually slow-growing and benign, although some may be malignant. Meningiomas are more common in adults, particularly in women.
3)Metastatic tumors: Metastatic brain tumors are secondary tumors that have spread to the brain from cancer originating in other parts of the body. Common primary sites for metastasis include the lungs, breasts, skin (melanoma), kidneys, and colon. Metastatic brain tumors are more common than primary brain tumors and can occur at any age.
4)Pituitary adenomas: Tumors that develop in the pituitary gland, situated at the base of the brain, are known as pituitary adenomas. These tumors disrupt hormone production and can cause a range of hormonal imbalances.
5)Medulloblastomas: Malignant brain tumors known as medulloblastomas usually affect children as they originate in the cerebellum, a crucial component of the brain that controls coordination and balance.

INCIDENCE

Brain tumor incidence is the rate of new cases of brain tumors diagnosed in a specific population within a given period, usually measured as the number of cases per 100,000 individuals annually. This rate provides critical information about the risk of developing brain tumors in different groups of people. Factors such as age, gender, race/ethnicity, and geographic location can affect the incidence rates of brain tumors. Among adults, gliomas, especially glioblastoma multiforme (GBM), are the most common malignant primary brain tumors, accounting for a considerable proportion of cases. Incidence of gliomas is generally higher in older adults. In children, medulloblastomas and other embryonal tumors are more frequently diagnosed compared to gliomas, with Brain tumor incidence rates ranging between 3 to 5 cases per 100,000 individuals per year.

PREVALENCE

Brain tumor prevalence is the total number of individuals who currently have brain tumors at a particular moment in time, and it reflects the overall burden of the disease in a population. The prevalence of brain tumors can be affected by different factors, such as advancements in diagnostic methods and improved survival rates resulting from innovative treatments. The exact prevalence of brain tumors can vary depending on factors such as the tumor type, age group, geographic location, and source of data. According to studies, estimates of brain tumor prevalence may range from 100 to 250 cases per 100,000 individuals in the general population, but this rate may vary in different populations or subgroups.

DIAGNOSTIC IMAGING TECHNIQUES

Diagnostic imaging techniques play a crucial role in the detection, characterization, and evaluation of brain tumors. Several imaging modalities are commonly used in clinical practice. Here are the key diagnostic imaging techniques used for brain tumor detection:

Computed Tomography (CT):
CT, which stands for Computed Tomography or CAT scan, is a method that utilizes X-rays to develop images of the brain in a cross-sectional manner. This technique provides comprehensive structural information and detects anomalies such as tumors, hemorrhages, and edema. CT scans are especially helpful in urgent situations as they can quickly evaluate acute conditions. Furthermore, the utilization of a contrast agent via intravenous injection can further amplify the brain tumor's visibility and sharpness in contrast-enhanced CT scans.

Magnetic Resonance Imaging (MRI):
Magnetic Resonance Imaging, or MRI, is a process that employs robust magnetic fields and radio waves to create comprehensive images of the brain. This technique is adept at establishing fine soft tissue contrast and has excellent sensitivity in detecting brain tumors. Multiple MRI sequences, including T1-weighted, T2-weighted, and post-contrast T1-weighted images, are commonly used to evaluate tumor features, including its location, scope, and accompanying changes in the surrounding brain tissue. Sophisticated methods such as diffusion-weighted imaging (DWI) and magnetic resonance spectroscopy (MRS) can also provide supplementary insights into the tumor's cellularity and metabolic activity.

Positron Emission Tomography (PET):
Positron Emission Tomography, or PET, is a technique that requires the infusion of a radioactive tracer, usually a glucose analog (FDG), that releases positrons. This projection of radiation is identified by a PET scanner, generating images that mirror metabolic activity in the brain. PET scans are beneficial in studying tumor metabolism and distinguishing between non-cancerous and cancerous tumors. Additionally, PET can be utilized with exact radiotracers that aim molecular markers identified with brain tumors.

III. METHODOLOGY

TUMOR IMAGE CLASSIFICATION USING CNN

As an automated and dependable classification tool, Convolutional Neural Network, or CNN, is perfect for detecting even the slightest details due to its robust structure. The deep-learning method, known as Convolutional Neural Network (ConvNet/CNN), is a specialized system utilized in various applications, capable of analyzing an input image, detecting and ranking diverse characteristics and objects within the image. Through efficient training, filters/traits can be learned, although the process of manually designing filters remains in use for fundamental processes.

By utilizing appropriate filters, a ConvNet can effectively comprehend the temporal and spatial relationships within an image, achieving a better fit with the image dataset. This is due to the decreased number of variables and the ability to recycle weights. Essentially, the network can be trained to more accurately gauge the complexity level of the image. The ConvNet aims to reduce the complexity of the images in a way that doesn't compromise the crucial elements necessary for precise prediction.

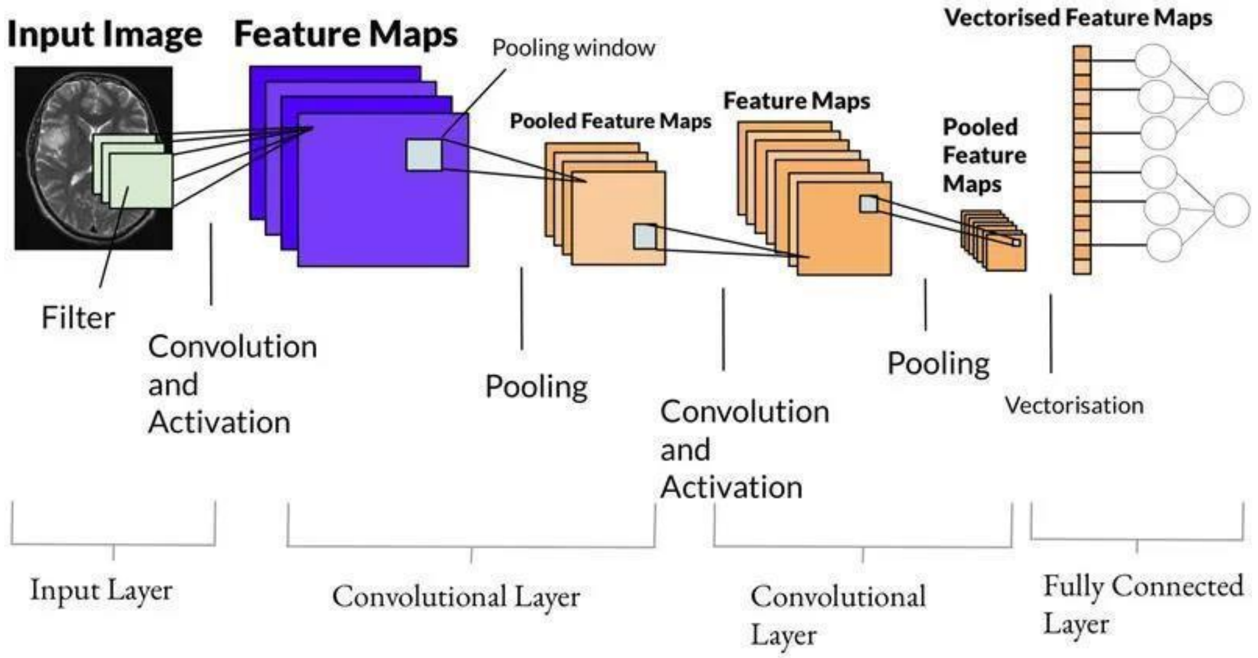

Fig : General Architecture Of CNN

The proposed system has the following steps for detection of disease:

Grey Scale: The initial step involves converting the input medical image, such as an MRI or CT scan, into a grayscale representation. This simplifies the subsequent image processing tasks by removing color information while retaining structural details.

Noise Removal: Noise present in the image can interfere with accurate tumor detection. Therefore, the system employs advanced noise removal techniques, such as filtering algorithms, to reduce unwanted artifacts and enhance image quality.

Thresholding: Thresholding is applied to segment the image and separate the tumor region from the surrounding healthy tissues. By setting an appropriate intensity threshold, pixels within the tumor region can be distinguished from the background.

Image Sharpening: Image sharpening techniques are employed to enhance the edges and fine details within the tumor region. This step helps in improving the visibility of tumor boundaries and facilitating accurate feature extraction.

Feature Extraction: In this step, relevant features or characteristics are extracted from the preprocessed image. These features may include shape descriptors, texture information, or statistical properties, which provide discriminative information for tumor classification.

Classification: The final step involves the use of machine learning algorithms or deep learning models to classify the extracted features and determine whether a tumor is present or not. The system utilizes a training dataset comprising labeled images to train the classifier, enabling it to differentiate between normal brain tissues and different types of tumors. The classification output may include the tumor type, grade, and other relevant information.

IV. CONCLUSION

The most effective imaging type for detecting brain tumor's is MRI. For the purpose of this work, brain tumor detection by MRI scans requires the use of CNN and digital image processing techniques. The various preprocessing techniques include edge identification, contrast enhancement, and filtering, among others. The preprocessed images are used for image enhancement post processing procedures as threshold, histogram, segmentation, and morphological. The predicted strategy is to detect brain tumor successfully, despite the fact that the tumor identification problem is very unbalanced with substantial intra-class variance. Convolutional neural networks will be used to build a candidate proposal approach that is anticipated to boost the precision for all recall levels.

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