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Leveraging U-Net Architecture for Accurate Localization in Brain Tumor Segmentation

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***Abstract*—This study presents an approach based on deep learning to segment brain tumors in medical imaging accurately. The segmentation of brain tumors plays a crucial role in diagnosing, planning treatments, and monitoring disease progression. However, existing methods have limitations such as time-consuming procedures, inadequate accuracy, and delayed detection. The U-Net model architecture, a widely used convolutional neural network (CNN) for medical image segmentation tasks, was employed to segment brain tumors in CT and MRI scans to overcome these challenges. The performance of the U-Net model was evaluated on datasets consisting of 32, 64, and 128 slices, respectively. The results demonstrated the achievement of the highest percentage of mean Intersection Over Union (IOU), with an impressive 80.89% for brain tumor segmentation. These results outperformed other existing methods. The proposed model exhibits the potential to reduce manual segmentation time and subjectivity while enhancing the accuracy of brain tumor diagnosis, treatment planning, and disease monitoring. This research contributes to the field by addressing the problem of brain tumor detection and showcasing the promising results attained using deep learning techniques.**

Keywords— U-Net, convolutional neural network, brain tumor segmentation, deep learning, MRI scan

I. INTRODUCTION

A brain tumor refers to an abnormal growth or mass of cells within the brain. Due to the rigid structure of the skull, any change within this confined space can lead to various issues. Brain tumors can be classified into different types, including benign (non-cancerous) and malignant (cancerous) tumors, originating from other cell types within the brain. These tumors can affect individuals of all ages, and their growth rates can vary, with some tumors exhibiting rapid growth while others grow slowly. Regardless of their cancerous nature, large brain tumors can exert pressure on surrounding tissues, potentially impacting brain function. Hence, early treatment is crucial to prevent further deterioration. The choice of brain tumor treatment depends on symptoms, tumor type, size, and location [1].

Among brain tumors, gliomas are the most common and originate from glial cells, which provide support and protection to nerve cells. Gliomas can be classified into Astrocytoma, Oligodendroglioma, and Ependymoma [2]. Other types of brain tumors include meningiomas, which develop in the meninges (protective covering of the brain and spinal cord), and pituitary tumors, originating in the pituitary gland.

Brain tumors can be categorized as primary or secondary. Primary brain tumors begin in the brain itself, although they are rare. In some cases, tumors can detach and spread to other brain and spinal cord parts. On the other hand, secondary brain tumors, also known as metastatic brain tumors [3], start as cancer in other body parts, such as the lungs or breasts, and subsequently metastasize to the brain. This type of brain tumor exhibits rapid growth and poses a significant danger.

Symptoms of brain tumors may include headaches, seizures, changes in vision or hearing, difficulties with balance or coordination, and cognitive impairments like memory loss or language difficulties. The manifestation of these symptoms can vary depending on the tumor's location and may only become noticeable once the tumor has considerably enlarged.

Accurate segmentation of brain tumors is a crucial step in detecting and managing brain tumors. It allows for precisely determining the tumor's size, shape, and location [1], which can inform treatment planning and prognosis prediction. In recent years, deep learning models have demonstrated promising results in medical image segmentation tasks, including brain tumor segmentation. This literature review aims to provide an overview of the current research in brain tumor segmentation using deep learning models.

In the domain of brain tumor segmentation, a comprehensive examination of deep learning models and pre-processing techniques was conducted in the study by [4]. The authors astutely observed that normalizing MRI images significantly enhanced the model's performance. Similarly, in another study by Munir, Frezza, and Rizzi, researchers effectively utilized histogram equalization to improve the contrast of MRI images and enhance the efficacy of the U-Net-based deep learning model [5].

In another noteworthy study, Zhao et al. evaluated a proposed model compared to widely used models for medical image segmentation, including U-Net, Attention U-Net, and ResUNet. The findings demonstrated the superiority of the proposed model across various evaluation indices [6]. Visual representations of the segmentation results from the esteemed BraTS 2020 dataset showcased the proposed model's ability to accurately locate lesion areas and generate precise edge

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