Post-Treatment Brain Tumor Segmentation of High- and Low-Grade Gliomas Using U-Net on the BraTS 2024 Dataset

Brain tumor segmentation from magnetic resonance imaging (MRI) is a critical component in modern neuro-oncology, serving as a foundation for evaluating treatment response, monitoring tumor progression, and planning further clinical interventions. Accurate segmentation of tumor regions significantly enhances clinicians' ability to assess disease status and make informed therapeutic decisions. The Brain Tumor Segmentation (BraTS) 2024 dataset provides a large-scale, standardized, and expertly annotated collection of post-treatment MRI scans that capture the complex morphology of gliomas after surgery, radiation, and chemotherapy. This dataset enables the development of robust machine learning and deep learning models that can generalize across diverse clinical scenarios.In this study, we propose a deep learning-based segmentation approach aimed at accurately delineating multiple tumor subregions, including Enhancing Tissue (ET), Non-Enhancing Tumor Core (NETC), Surrounding Non-Enhancing FLAIR Hyperintensity (SNFH), and Resection Cavity (RC). Our research specifically targets post-treatment high-grade and low-grade gliomas, where the differentiation between these subtypes is crucial due to their distinct biological behaviors. High-grade gliomas (HGGs) are known for their aggressive nature and high recurrence rates, even after surgical resection, while low-grade gliomas (LGGs) typically exhibit slower growth but may progress to higher grades over time. Post-treatment imaging, therefore, plays a pivotal role in predicting patient survival, assessing residual tumor burden, and identifying early signs of recurrence. To achieve precise segmentation, we employ the U-Net architecture, leveraging its encoder–decoder structure that effectively captures both fine-grained spatial features and global contextual information from multimodal MRI sequences (T1, T1ce, T2, and FLAIR). The model will be trained and validated on the BraTS 2024 dataset, with performance evaluated using established metrics such as the Dice Similarity Coefficient (DSC), sensitivity, and specificity. Through this research, we aim to contribute a reliable and efficient segmentation framework that enhances the accuracy of post-treatment glioma analysis. The outcomes of this study are expected to support clinical decision-making, improve prognosis estimation, and advance the integration of automated image analysis tools into clinical practice, ultimately fostering personalized treatment planning and better patient outcomes in neuro-oncology.