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ARTICLE

ResMHA-Net: Enhancing Glioma Segmentation and Survival Prediction Using a Novel Deep Learning Framework

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ABSTRACT

Gliomas are aggressive brain tumors known for their heterogeneity, unclear borders, and diverse locations on Magnetic Resonance Imaging (MRI) scans. These factors present significant challenges for MRI-based segmentation, a crucial step for effective treatment planning and monitoring of glioma progression. This study proposes a novel deep learning framework, ResNet Multi-Head Attention U-Net (ResMHA-Net), to address these challenges and enhance glioma segmentation accuracy. ResMHA-Net leverages the strengths of both residual blocks from the ResNet architecture and multi-head attention mechanisms. This powerful combination empowers the network to prioritize informative regions within the 3D MRI data and capture long-range dependencies. By doing so, ResMHA-Net effectively segments intricate glioma sub-regions and reduces the impact of uncertain tumor boundaries. We rigorously trained and validated ResMHA-Net on the BraTS 2018, 2019, 2020 and 2021 datasets. Notably, ResMHA-Net achieved superior segmentation accuracy on the BraTS 2021 dataset compared to the previous years, demonstrating its remarkable adaptability and robustness across diverse datasets. Furthermore, we collected the predicted masks obtained from three datasets to enhance survival prediction, effectively augmenting the dataset size. Radiomic features were then extracted from these predicted masks and, along with clinical data, were used to train a novel ensemble learning-based machine learning model for survival prediction. This model employs a voting mechanism aggregating predictions from multiple models, leading to significant improvements over existing methods. This ensemble approach capitalizes on the strengths of various models, resulting in more accurate and reliable predictions for patient survival. Importantly, we achieved an impressive accuracy of 73% for overall survival (OS) prediction.

KEYWORDS

Glioma; MRI; segmentation; multihead attention; survival prediction; deep learning