Brain Tumor Segmentation and Classification Based on Deep Learning, Attention Mechanisms, and Energy-Based Uncertainty Predictions

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A brain tumor is a foreign growth within the brain that disrupts function. Brain tumors are one of the most deadly forms of cancer with a mortality of 80%. As a result, a quick and accurate diagnosis is crucial for survival. Typically, brain tumors are diagnosed through a series of MRIs and biopsies that are manually annotated by neuroradiologists and other specialized physicians. These evaluations are costly, time-consuming, and have high degrees of error due to their complexity. To aid in this process, various models were proposed for brain tumor and glioma classification, region of interest detection, multi-class segmentation, and uncertainty estimations. The classification models achieved state-of-the-art results when classifying gliomas, meningiomas, pituitary tumors, astrocytomas, glioblastomas, and oligodendrogliomas by outperforming their contemporaries. The proposed convolutional neural networks (CNNs) implemented strided convolutions, batch normalization, and hyperparameter Bayesian optimization to decrease data loss and find ideal hyperparameters. These models classified brain tumors and gliomas with an accuracy of 98.4% and 99.05%, respectively. The segmentation model achieved state-of-the-art results with dice scores of 89.6, 89.2, and 85.5 for the peritumoral edema, non-enhancing tumor core, and enhancing tumor regions on the BraTS 2020 dataset. Due to potential noise and the imperfection of the model, an energy-based model (EBM) was used for voxel-based uncertainty estimations. Using the uncertainty estimation of each voxel, physicians can trust the tumor regions where the model is confident and ignore the uncertain areas. Overall, the proposed models significantly outperformed previous works and expedites brain tumor diagnosis.