Discerning and Demarcation of Various Grades of Gliomas from Magnetic Resonance Brain Images Using Machine Learning Techniques for Early Prediction in Therapeutic Applications

Gliomas are the most common and aggressive type of brain tumor, often leading to a significantly reduced life expectancy in their most severe forms. Accurate diagnosis and treatment planning play a crucial role in improving the overall quality of life for oncology patients. Magnetic Resonance Imaging (MRI) is widely used for examining these tumors; however, the large amount of data generated by MRI makes manual segmentation impractical, limiting the use of precise quantitative assessments in clinical practice. Precise segmentation of gliomas and their intra-tumoral structures is essential not only for treatment planning but also for follow-up evaluations. The task is challenging due to the significant variation in shape, size, and location of these tumors. Consequently, fully automated and reliable segmentation techniques are required, though the wide spatial and structural diversity of brain tumors makes automatic segmentation a complex problem.

Machine Learning (ML), a subset of Artificial Intelligence (AI), enables software applications to improve their predictive accuracy over time. In image processing, ML techniques can accurately identify and segment regions of interest within medical images. In this research, we propose an automatic segmentation approach that integrates clustering and optimization algorithms to achieve an optimal solution for the segmentation problem. The proposed method is validated using BraTS challenge datasets from 2013, 2015, 2018, 2019, 2020, and 2021. The effectiveness of the developed method is evaluated by comparing the results with ground truth images provided by expert, board-certified neuroradiologists. Performance metrics—including computational time (T), Mean Squared Error (MSE), Peak Signal-to-Noise Ratio (PSNR), Tanimoto Coefficient (TC), Dice Overlap Index (DOI), Similarity Index (SI), Overlap Fraction (OF)/Sensitivity, Specificity, and Extra Fraction (EF)—are calculated and compared with existing state-of-the-art methods to demonstrate the robustness and reliability of the proposed approach.

Keywords: Glioma, Segmentation, Machine Learning, Optimization, BraTS