SUBREGION CLASSIFICATION OF GLIOMA MRI BASED ON LABEL WEIGHTING USING MACHINE LEARNING TECHNIQUES

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ABSTRACT

Gliomas are the most common primary brain tumors, accounting for 40% of all central nervous system tumors and 80% of malignant brain tumors. It comprises the following subregions: necrotic core, peritumoral edema, and enhancing (ET) and non-enhancing tumor (NET). Subregion classification aids in grading gliomas by evaluating the presence and extent – ET/NET as it is indicative of tumor aggressiveness. This study focused on classifying subregions using T1, T2, T1CE, and fluid-attenuated inversion recovery (FLAIR) magnetic resonance imaging (MRI) sequences. A novel label weighting-based approach seeks to provide a robust framework for clinical decision-making and personalized therapeutic strategies. This study is implemented on BraTS 2018, 2019, and 2020 datasets. To ensure uniformity in pixel intensity values across diverse images, pre-processing was implemented using max–min normalization. The pipeline integrated 3D segmentation using a modified UNET and subregion classification using a weighting technique to balance label contributions, along with the least absolute shrinkage and selection operator for consistent feature representation. This work investigates the performance of the proposed technique on LightGBM, XGBoost, and SVM classifiers. The network is trained on 80% and validated on 20% of the data. Performance assessment was based on metrics such as accuracy, precision, sensitivity, and F1 score. This method, incorporated a modified UNET architecture for segmentation, achieved remarkable performance metrics for LightGBM with a classification accuracy of 97.0%, precision of 94.0%, sensitivity of 93.0%, and an F1 score of 94.0%. These results have potential implications for improving clinical workflows and enhancing patient outcomes through accurate glioma classification.

Keywords: Glioma, Subregion Classification, MRI, UNET, Machine Learning, Segmentation

INTRODUCTION

Gliomas are a heterogeneous group of brain tumors originating from glial cells in the central nervous system [1]. These are among the most common and aggressive types of brain tumors, and their accurate classification is essential for effective treatment planning and patient management. Gliomas are classified into various subregions/subclasses, including necrotic core (NCR), peritumoral edema (ED), and enhancing and non-enhancing tumor regions (ET/NET), each with distinct morphological characteristics and clinical implications [2]. Accurate classification of these subregions is crucial for developing effective treatment strategies, as gliomas can range from benign, slow-growing forms to malignant, rapidly progressing types. Current research highlights the challenges in distinguishing between these classes, with machine learning (ML) techniques offering promising improvements in classification accuracy.

Magnetic Resonance Imaging (MRI) is a crucial tool in glioma diagnosis, providing detailed insights into tumor characteristics through various imaging modalities, such as T1-weighted, T1 with contrast enhancement, T2-weighted, and Fluid-Attenuated Inversion Recovery (FLAIR) sequences. Despite advancements in imaging technology, the interpretation of MRI data remains challenging due to the