Archives of Computational Methods in Engineering
https://doi.org/10.1007/s11831-024-10188-2

REVIEW ARTICLE

A Critical Review on Segmentation of Glioma Brain Tumor and Prediction of Overall Survival

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Received: 15 January 2024 / Accepted: 3 September 2024

Abstract
In recent years, the surge in glioma brain tumor cases has positioned it as the 10th most prevalent tumor affecting individuals across diverse age groups. Gliomas, characterized by their invasive nature, unpredictable localization, and heterogeneous subregions, pose a substantial threat to public health. Accurate segmentation of glioma subregions within magnetic resonance imaging (MRI) images is pivotal for the efficient planning of treatment and the prognostication of overall patient survival. This review examines recent advancements in glioma brain tumor segmentation (BTS) and overall survival (OS) prediction while addressing inherent biases and proposing innovative solutions. We explore the evolution of convolutional neural network (CNN) architectures, from traditional 2D CNNs to advanced 2.5D and 3D CNNs, which have greatly enhanced segmentation accuracy and efficiency. Furthermore, cutting-edge techniques for BTS, including attention mechanisms, ensemble methods, transformer-based models, and generative adversarial networks (GANs), are discussed. Additionally, we examine machine learning (ML) models for OS prediction, including support vector machines (SVM) and random forest regressors (RFRs), as well as pioneering methods such as radiomics-based approaches, consensus-based classifiers, and explainable artificial intelligence (XAI). By comparing different preprocessing techniques, model architectures, data sources, and evaluation metrics, we identify the most effective methods and emphasize the importance of collaboration in developing reliable prognostic tools. By consolidating current research, this paper advances ongoing investigations and offers a visionary path for future studies, providing guidance to healthcare stakeholders for refining patient care strategies in glioma management.

1 Introduction

The human brain, ensconced within the protective cranium, orchestrates essential bodily functions vital for life. Nevertheless, any abnormal growth occurring within this limited space can lead to severe complications. One such complication is a brain tumor, which is a malformed mass of tissue that arises within the human brain [1]. There are two kinds of brain tumors: primary and secondary. Primary tumors develop within the brain and are more prevalent than secondary tumors, which metastasize to the brain from other areas of the body [2]. Brain tumors are categorized into four grades by the world health organization (WHO), spanning from I to IV. Grades I and II indicate benign tumors, while grades III and IV represent malignant tumors. Among benign brain tumors, including meningioma, pituitary adenoma, glioma, and others, gliomas are the most prevalent type of brain tumor in adults [3]. Gliomas have been additionally classified by the world health organization (WHO) into 4 grades, spanning from grade I to IV, determined by histological characteristics encompassing cell abnormalities, proliferation rate, and invasiveness. Furthermore, gliomas classified as grades I and II are designated as low-grade gliomas (LGG), whereas those categorized as grades III and IV are identified as high-grade gliomas (HGG) [4]. Grade 4 glioma brain tumors, alternatively referred to as glioblastoma tumors, are particularly aggressive and present significant challenges in achieving accurate diagnoses. HGGs are characterized by distinct regions, including the core/necrotic, edema, non-enhancing, and enhancing areas, each with varying cellular compositions. These differences pose a significant challenge in precisely diagnosing and measuring tumor volume. Furthermore, delineating these regions in magnetic

Communicated by Novsheena Rasool.

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Published online: 17 October 2024