IEEE Access
Multidisciplinary | Rapid Review | Open Access Journal

Received 27 June 2025, accepted 11 July 2025, date of publication 16 July 2025, date of current version 25 July 2025.

Digital Object Identifier 10.1109/ACCESS.2025.3588619

RESEARCH ARTICLE

T3SSLNet: Triple-Method Self-Supervised Learning for Enhanced Brain Tumor Classification in MRI

MD. NASIF SAFWAN[1], (Student Member, IEEE), SOUHARDO RAHMAN[1], (Student Member, IEEE), MAHAMODUL HASAN MAHADI[1], (Graduate Student Member, IEEE), MD IFTEKHARUL MOBIN[1], (Member, IEEE), TAHARAT MUHAMMAD JABIR[1], (Student Member, IEEE), ZEYAR AUNG[2], (Senior Member, IEEE), AND M. F. MRIDHA[1], (Senior Member, IEEE)

[1]Department of Computer Science, American International University-Bangladesh, Dhaka 1229, Bangladesh
[2]Department of Computer Science, Khalifa University, Abu Dhabi, United Arab Emirates

Corresponding authors: M. F. Mridha (firoz.mridha@aiub.edu) and Zeyar Aung (zeyar.aung@ku.ac.ae)

The authors gratefully acknowledge the financial support provided by Khalifa University, United Arab Emirates.

ABSTRACT Classification of brain tumors from MRI images is crucial for early diagnosis and effective treatment planning. However, there are still obstacles to overcome, including low image quality, sparsely labeled data, and variability in tumor characteristics. In this study, we explored the use of self-supervised learning techniques to improve the classification performance for brain tumors. Specifically, we tested three SSL approaches SimCLR, MoCo, and BYOL, with ResNet-50 as the backbone architecture on a newly constructed dataset created by combining five public datasets. We further extended our work by integrating EfficientNet to evaluate its computational efficiency, demonstrating its feasibility for low-processor systems. We introduce T3SSLNet, a novel framework consisting of four key components: the imaging spectrum enhancement block for data augmentation, the Frozen Feature Extractor block for hierarchical feature extraction, Neural Representation Projection Learning block for contrastive-positive pair learning, and Unfrozen Classification block for tumor classification. Our experimental results paired with ResNet-50 indicate that, without fine-tuning, MoCo achieved the highest accuracy at 95.76%, followed by SimCLR at 92.25% and BYOL at 81.80%. Following fine-tuning, BYOL showed a significant improvement, reaching 96.42%, while MoCo and SimCLR reached 96.87% and 97.02%, respectively.

INDEX TERMS Brain tumor classification, contrastive-positive pair learning, pre-training, ResNet, self supervised learning.

I. INTRODUCTION

The intricate network of the brain, comprising billions of cells, can be disrupted by abnormal cell growth, resulting in tumor formation [1]. The size, form, and type of these tumors vary greatly, and numerous medical imaging methods have been developed to diagnose them [2]. Among these, MRI is the preferred modality because of its ability to generate high-fidelity images that offer accurate information on the anatomy of the brain [3]. It is particularly effective for visualizing and classifying different types of brain tumors, such as meningioma, glioma, and pituitary tumors [4].

In recent years, significant advancements have been made in the field of brain tumor classification by leveraging the power of neural networks and machine learning. These methods have shown remarkable accuracy and efficiency, pushing the boundaries of medical diagnostics and offering new hope for early and accurate detection of brain tumors.

The associate editor coordinating the review of this manuscript and approving it for publication was Ines Domingues.