

Addressing Domain Shift in Low-Resource Neuroimaging: Glioma Segmentation for Sub-Saharan MRI

Accurate segmentation of gliomas from magnetic resonance imaging (MRI) is central to clinical diagnosis and treatment planning. Yet, performance degrades when models trained on high-resource datasets are applied to Sub-Saharan African (SSA) scans, which often suffer from heterogeneous acquisition protocols, reduced resolution, and limited annotations. This domain gap has reinforced inequities in neuro-oncology outcomes, as robust automated tools remain largely unavailable in low-resource regions where they are most needed [1].

We propose a domain-adaptive transformer framework that integrates intensity harmonization with architectural refinements for improved robustness in SSA neuroimaging. Our method builds on a SegFormer-based volumetric backbone [2], augmented with a wavelet-convolutional input stem for frequency-aware encoding and dual attention modules for joint spatial-channel refinement [3]. The decoder incorporates radiomics-guided stratification [4] to enhance tumor boundary detection under low-contrast conditions. To mitigate domain shift, we apply histogram matching [5] between SSA and high-quality BraTS 2023 adult glioma scans [6], followed by pretraining on BraTS 2023 and fine-tuning on BraTS-Africa [1]. This pipeline requires only 12M parameters and achieves $2.3\times$ faster inference than comparable CNN approaches, making it suitable for deployment in resource-constrained healthcare environments.

Datasets: The BraTS 2023 adult glioma dataset [6] comprises 1,251 cases with multi-parametric MRI (T1w, T1w-CE, T2w, FLAIR) and expert-verified annotations of tumor subregions. BraTS-Africa [1] extends this benchmark to low-resource settings with 60 labeled and 35 validation cases from SSA institutions, reflecting real-world challenges such as lower field strength, acquisition variability, and reduced image contrast.

Result: On BraTS-Africa, our approach achieves mean Dice of 0.842 (vs. 0.589 for SSA-only training and 0.681 for direct BraTS 2023 transfer), representing a 43% improvement. Ablation studies reveal that histogram matching contributes +0.089 Dice while pretraining adds +0.164, with the largest gains observed for enhancing tumors, the most clinically relevant yet challenging subregion under low-contrast conditions. Our method outperforms recent domain adaptation baselines including CORAL [7] (+0.133 Dice) and adversarial training [8] (+0.147 Dice).

This work demonstrates that thoughtful domain adaptation can achieve clinically meaningful performance for glioma segmentation in Sub-Saharan African populations, addressing a critical gap in equitable healthcare AI. Future directions include expanding to multi-institutional SSA datasets and investigating generalization across other neurological conditions prevalent in underrepresented populations.

References

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