# ABSTRACT

## OPTIMIZED SMOTE AND RADIUS-SMOTE FOR DATA IMBALANCE IN MRI-BASED BRAIN TUMOR DETECTION

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Brain tumor detection using MRI plays a crucial role in clinical diagnosis, yet manual interpretation remains time-consuming and susceptible to human error. Machine learning and deep learning have significantly improved diagnostic reliability, but imbalanced MRI datasets continue to hinder model sensitivity toward minority tumor classes. This research proposes a hybrid framework that integrates VGG16 feature extraction with XGBoost classification, enhanced by advanced oversampling techniques including SMOTE, Radius-SMOTE, and Genetic Algorithm–optimized SMOTE (GA-SMOTE). Through systematic preprocessing and feature extraction, VGG16 produced high-quality latent representations, enabling efficient and robust classification. Experimental results show that the hybrid VGG16–XGBoost baseline outperformed the end-to-end VGG16 model, achieving higher accuracy with drastically reduced computation time. While standard SMOTE and Radius-SMOTE yielded negligible improvements, the GA-SMOTE pipeline demonstrated superior performance, reaching 95.78% accuracy with enhanced recall for minority tumor classes. These findings validate the effectiveness of hybrid models and optimization-based oversampling in improving diagnostic precision, particularly in scenarios where class imbalance affects medical imaging tasks. The proposed approach offers a reliable and computationally efficient solution for automated MRI-based brain tumor detection.

Keywords – Brain Tumor, MRI, Data Imbalance, VGG16, SMOTE, Genetic Algorithm, XGBoost, Classification.