# Efficient and Explainable Brain MRI Tumor Classification

**Abstract:** We present a lightweight MobileNetV2-based pipeline for brain MRI tumor classification with comprehensive external validation and domain adaptation. Internal validation achieved 96.0% accuracy, while external validation revealed 28% performance drop due to domain shift. Simple adaptation (recalibration + thresholds) improved external performance to 78.4% macro-F1 and glioma recall from 23% to 58%. The pipeline demonstrates real-time capability (45.7 images/second) with minimal resources (8.52 MB model, 2.22M parameters).

| Metric | Internal Test | External Baseline | External Adapted |
|---|---|---|---|
| Accuracy (%) | 96.0 | 72.3 | 78.4 |
| Macro-F1 (%) | 95.8 | 67.5 | 78.4 |
| Glioma Recall (%) | 90.6 | 23.0 | 58.0 |
| Parameters (M) | 2.22 | 2.22 | 2.22 |
| Latency (ms) | 21.88 | 21.88 | 21.88 |
| Model Size (MB) | 8.52 | 8.52 | 8.52 |

**Key Findings:** • **External Validation:** Significant domain shift identified (28% macro-F1 drop) • **Domain Adaptation:** Simple recalibration + thresholds effective (+10.9% improvement) • **Glioma Detection:** Dramatic improvement from 23% to 58% recall • **Efficiency:** Real-time performance on standard CPU hardware • **Calibration:** Domain-specific calibration essential for reliability • **Explainability:** Grad-CAM with high faithfulness scores (78-98%) **Clinical Impact:** Pipeline ready for clinical evaluation studies and radiologist assistance tools. Not yet suitable for unsupervised clinical use due to domain shift challenges, but provides practical adaptation strategies for real-world deployment.