

Focal Cortical Dysplasia Type II Detection Using Cross Modality Transfer Learning and Grad-CAM in 3D-CNNs for MRI Analysis

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Aims: Focal Cortical Dysplasia (FCD) type II is a frequent cause of drug-resistant epilepsy, often necessitating surgical intervention[1]. However, its detection in MRI is challenging due to subtle abnormalities[2]. This study aims to evaluate how transfer learning (TL) from segmentation to classification can improve diagnostic accuracy and the interpretability of deep learning (DL) models through explainable AI (XAI) tools, specifically Grad-CAM[3], for a better understanding of pathological zones. Cross-task TL is especially valuable in medical imaging, where single centers often have small datasets and may possess more data for related but different tasks.

Materials & Methods: We employed 3D convolutional neural networks (3D-ResNet-18, -34, and -50) to classify MRI scans (T1-weighted and FLAIR) from 170 subjects (85 FCD patients, 85 controls) [4]. Three TL strategies were tested: no TL, TL from a single segmentation task, and TL from 23 segmentation tasks[5]. To enhance interpretability, Grad-CAM was applied to highlight regions influencing model decisions. A novel metric, Heat-Score, was introduced to quantify model attention to clinically relevant areas.

Results: TL from segmentation tasks significantly boosted classification accuracy and model interpretability. The best-performing model (ResNet-50) achieved up to 80.3% accuracy (from 72.9% without TL) on FLAIR images and showed higher Heat-Scores, indicating better localization of epileptogenic zones. Heat-Score increased from 1.545 (no-TL) to 2.940 (23-segmentation TL), demonstrating improved model focus on pathological regions. Figure1 shows good classification/localization (a) and bad localization (b, c, d with low Heat-Score). These enhancements were statistically significant ($p < 0.05$), underscoring the importance of cross-task transfer learning in medical imaging.

Conclusion: Transfer learning from segmentation to classification not only improves diagnostic performance but also enhances the model's pathological understanding, as evidenced by higher Heat-Scores. These results highlight the importance of transfer learning, including cross-modality, and XAI in advancing AI-based medical diagnostics, especially for difficult-to-diagnose pathologies such as FCD.

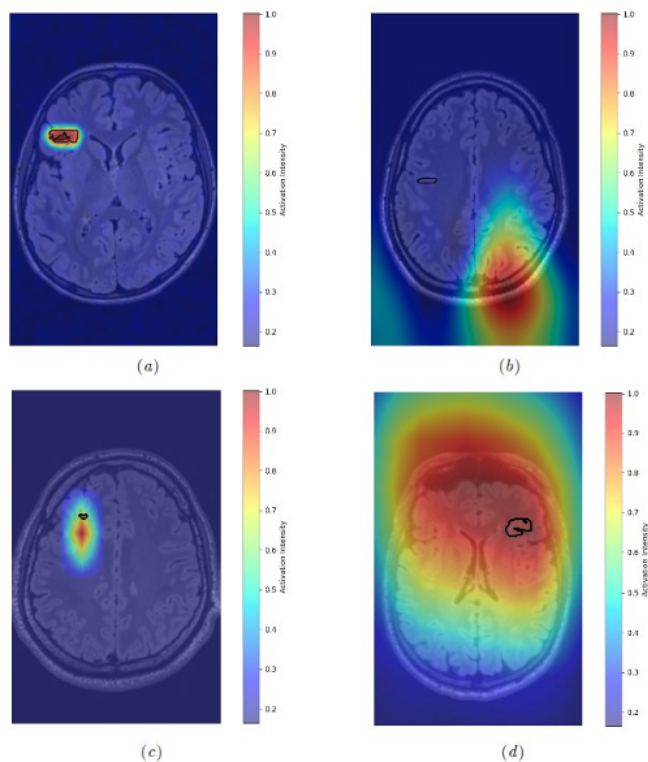


Figure 1

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