

Dual-Path Memory-Guided Swin Transformer for Interpretable Alzheimer's MRI Slice Classification

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Our study introduced a dual-path memory-guided Swin Transformer that enhances Alzheimer's MRI slice classification with superior accuracy, interpretability, and cross-dataset robustness through adaptive feature encoding and attention-based attribution.

INTRODUCTION

Motivation: Structural MRI can detect early brain abnormalities in AD, but current deep learning models often lack feature modeling for small anomalies and interpretability.

Objective: To introduce an end-to-end, interpretable Swin Transformer architecture that improves **cross-slice structural modeling** and provides **decision transparency** through attribution proof.

METHODS

Methods: We extracted and augmented 2D slices from three public MRI datasets, then applied a Swin Transformer encoder-decoder with dual-path memory-enhanced encoding and deformable cross-attention reconstruction to generate attribution maps, evaluated via five metrics with 8:1:1 splits, ablation, and cross-dataset transfer. (Fig.1)

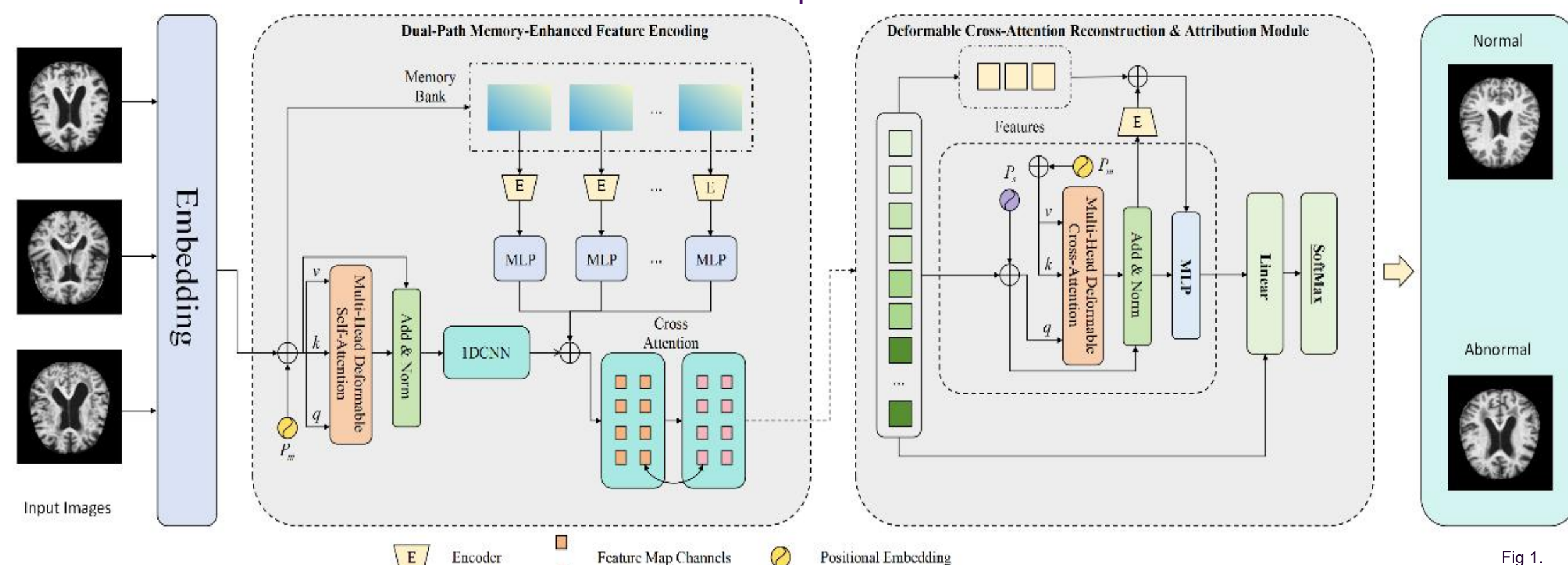


Fig 1.

RESULTS

Performance:

Dataset 1 (Kaggle-AD4): Accuracy 0.9914 ± 0.0021 , AUC 0.9997 ± 0.0008 .

Dataset 2 (Kaggle-AD2): Accuracy 0.9531 ± 0.0027 , improving over Swin Transformer baseline by 2.8–3.1%.

Dataset 3 (OASIS): Accuracy 0.9951 ± 0.0019 , AUC 0.9999 ± 0.0007 . (all $p < 10^{-7}$) (Fig5.)

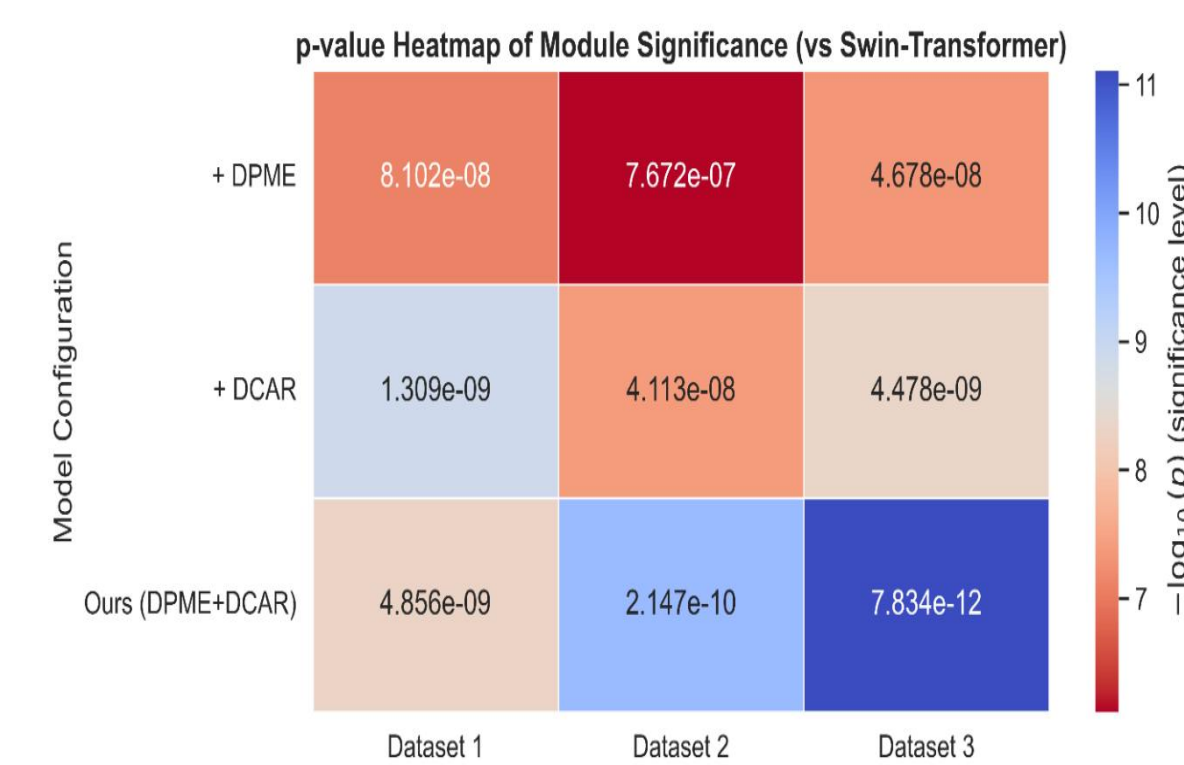


Fig 5. Thermograph of significance analysis of ablation experiment.

Visualizations:t-SNE and Grad-CAM supported clearer class separability and more lesion-relevant attention compared with baselines. (Fig7-8.)

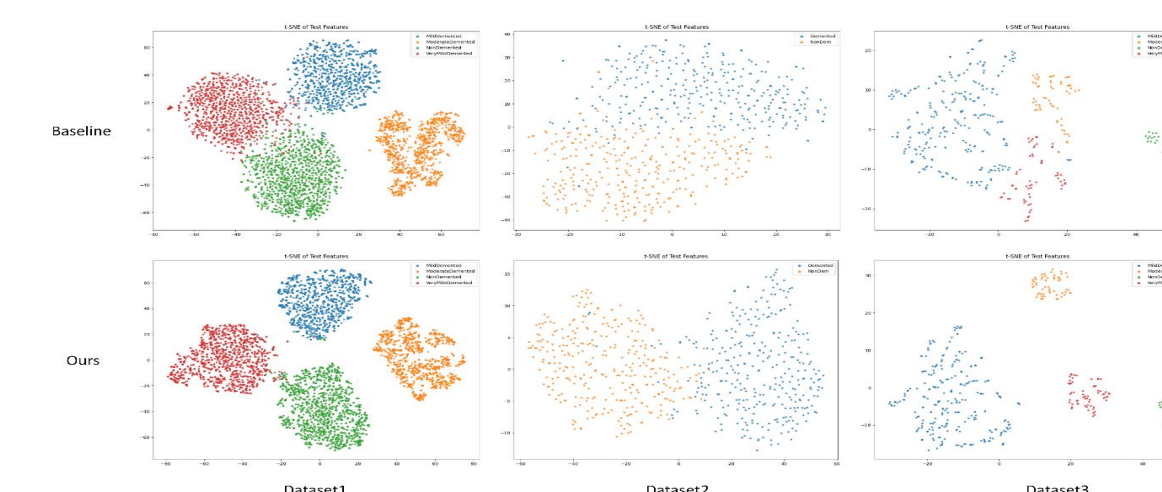


Fig 7. Results of t-SNE experiments on three datasets.

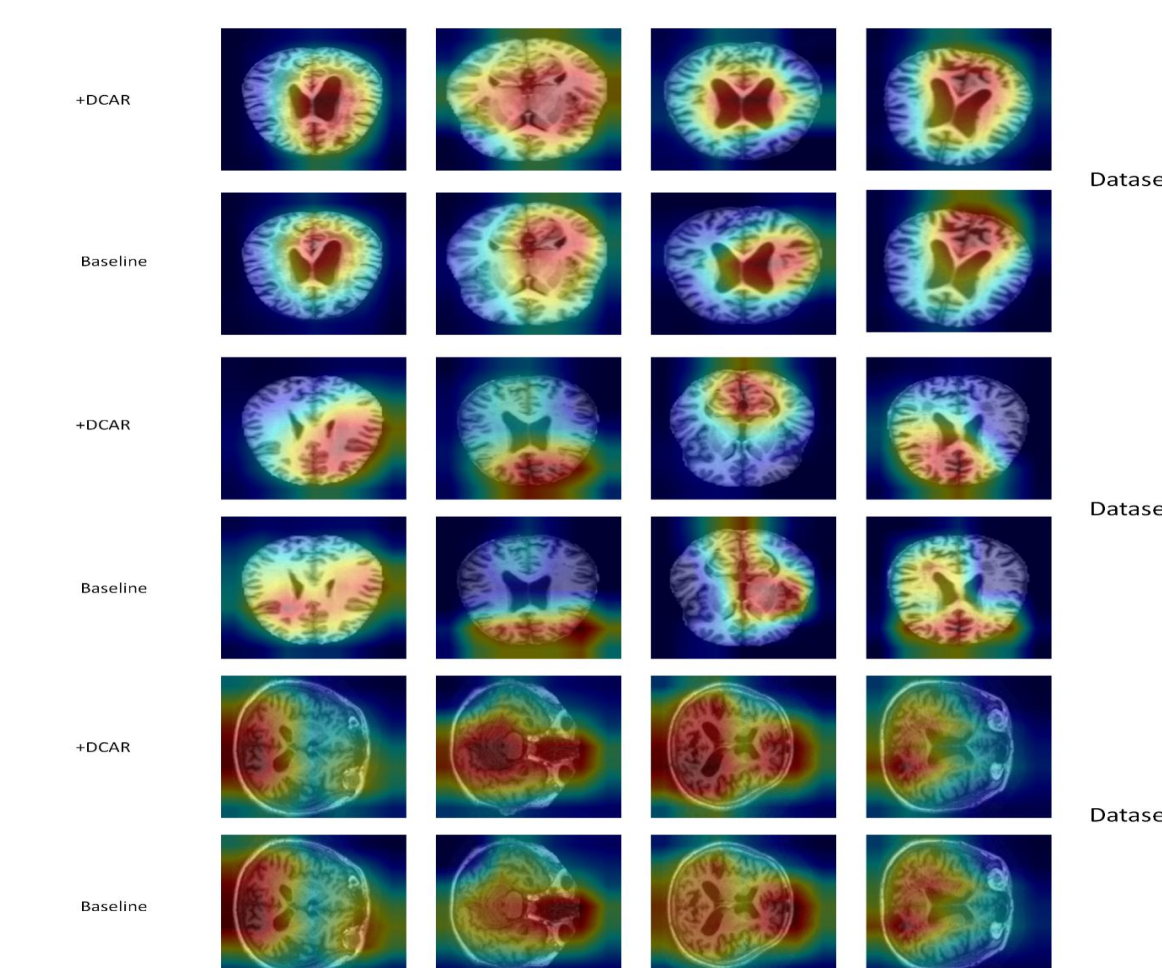


Fig 8. Results of Grad-cam experiments on three datasets.

CONCLUSIONS

Dual-path memory and adaptive cross-attention reconstruction can improve Alzheimer's disease magnetic resonance imaging slice classification, interpretability, and cross-dataset robustness, supporting transparent neuroimaging-assisted decision-making.

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