Cascaded Coarse-to-Fine Segmentation for Hippocampal Structures in Low-Field Neonatal MRI

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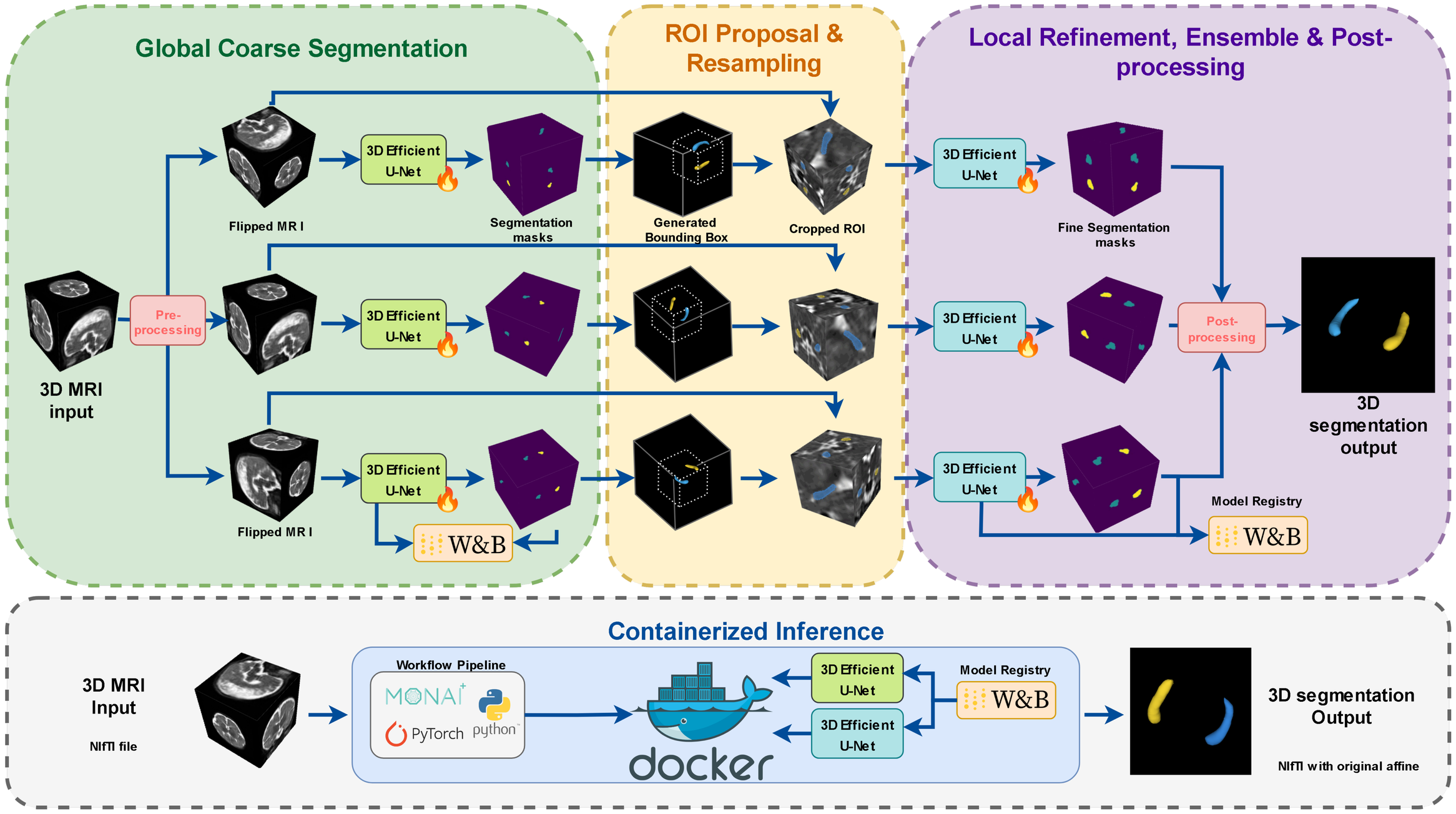

Figure 1. Coarse-to-fine cascaded pipeline for hippocampal MRI segmentation, including global segmentation, ROI cropping, local refinement, and reproducible inference via Docker.

1. Introduction

RISE-MICCAI Challenge: Hippocampal segmentation in 0.064T pediatric Low-field MRI for assessing neurodevelopmental trajectories and identifying early markers of neurological disorders.

Problem: Poor contrast, motion artifacts, existing tools fail on low-field pediatric data.

2. Preprocessing

Pipeline:

- Reorient → RAS
- Intensity scale
- CropForeground
- Resample → 1mm isotropic
- Morphological cleanup:

– Remove <10 voxels

– Closing=2, Opening=1

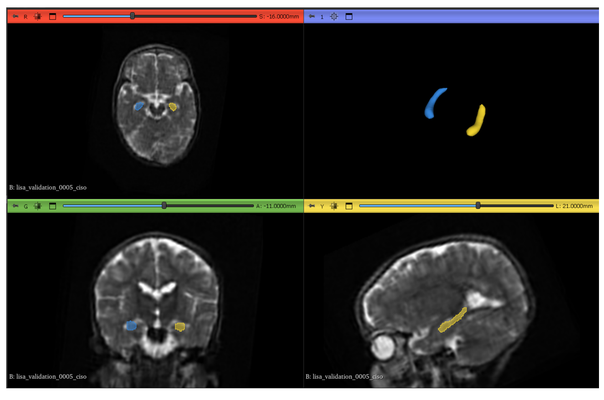

Figure 2. Example of 3D MRI data.

3. Two-Stage Cascade Architecture

Training: • 5-fold CV (by patient ID) → robust generalization

Stage 1 – Coarse:

- EfficientNet-B2 U-Net @ 192^3
- Adaptive ROI thresholds

Stage 2 – Fine:

- ROI @ 96^3 (+25 margin)
- BalancedDiceCELoss

Test-Time Aug:

- Ensemble = Original + coronal flip + axial flip
- Probability averaging → better boundaries

Laterality Preservation in TTA

Design Choice:

- No sagittal flips → swaps L/R, breaks labels
- Use only coronal + axial flips
- Preserves anatomical laterality
- Ensures robust L/R predictions

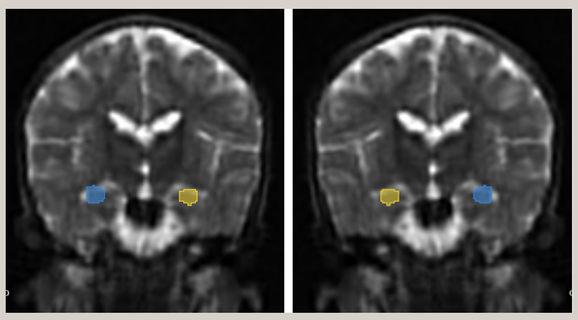

Figure 3. Example of sagital flip.

4. Results

The cascade architecture demonstrates significant improvements over single-stage approaches. Brain-focused preprocessing proves essential for model convergence, while the two-stage refinement achieves precise boundary delineation. The ensemble of three TTA predictions (original + two anatomically-safe flips) provides consistent improvement of 5% DSC.

Pipeline Stage	DSC	DSC-L/R	HD95_avg(mm)
Without preprocessing	0.498	0.502/0.494	5.86
Coarse with preprocessing	0.582	0.591/0.573	4.21
Fine cascade	0.621	0.650/0.642	2.45
Fine cascade 3 views	**0.672**	**0.681/0.663**	**2.41**

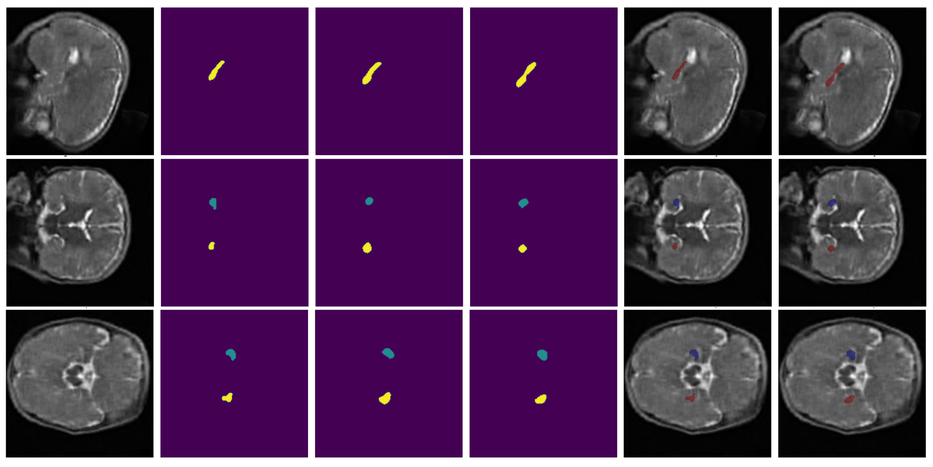

Figure 4. Input MRI, ground truth, coarse prediction, fine prediction, GT overlay, prediction overlay.

5. Key Contributions

Reproducibility:

- Consistent outputs across full pipeline • W&B for model versioning (5 folds)
- Preserved affine matrix for anatomical alignment

Deployment:

- Containerized pipeline (Docker + MONAI + PyTorch) • Automated inference → CISO inputs → compliant NIfTI outputs • 45s/scan on GPU

Impact:

- Deployment-ready in low-resource settings • Enables hippocampal assessment with 0.064T MRI • Fills critical gap in pediatric neuroimaging

6. Acknowledgments & Code

Acknowledgments: • Thanks to RISE-MICCAI 2025 organizers for challenge & dataset

Open Science: • Full implementation publicly available. Supports reproducible research in low-resource settings

Code available

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