Supplementary Information

Distance-to-Ventricle Guided Deep Learning for Periventricular and Deep Multiple Sclerosis Lesion Segmentation

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Reference numbers in square brackets refer to the reference list of the main article.

Supplementary Table S1. Comparison of base models (no distance channel). Dice: pooled lesion (PV + deep), mean over patients.

Model	Architecture	Params (M)	CV Dice	Test Dice
U-Net [24]	CNN encoder–decoder, plain skip connections	7.76	**0.758**	**0.760**
Swin UNETR [25]	Swin-transformer encoder, CNN decoder	1.59	0.693	0.693

Supplementary Table S2. Five-fold cross-validation Dice on the 70 development patients (mean ± SD over folds)

Class	Baseline U-Net	Distance U-Net
PV lesion	0.713 ± 0.024	**0.753** ± 0.008
Deep lesion	0.690 ± 0.026	**0.728** ± 0.015
Pooled lesion	0.758 ± 0.013	**0.761** ± 0.012
Normal WMH	**0.668** ± 0.010	0.666 ± 0.016
All WMH	**0.763** ± 0.007	0.760 ± 0.010
Ventricle	0.894 ± 0.003	**0.933** ± 0.005

Supplementary Table S3. Channel ablation on the test set (mean Dice, 30 patients). Cons.: share of predicted lesion voxels whose PV/deep label agrees with the true 10 mm geometry.

Input condition	Model	Pooled	PV	Deep	Cons.
Intact	Baseline U-Net	0.760	0.731	0.702	0.956
	Distance U-Net	0.763	0.758	0.738	0.991
No T2	Baseline U-Net	0.239	0.147	0.264	0.804
	Distance U-Net	0.490	0.491	0.435	0.980
No T1	Baseline U-Net	0.363	0.312	0.335	0.884
	Distance U-Net	0.617	0.630	0.482	0.942
No $z \pm 1$ slices	Baseline U-Net	0.705	0.599	0.549	0.824
	Distance U-Net	0.764	0.755	0.724	0.989
Donor DIST map	Distance U-Net	0.732	0.556	0.534	0.757

Supplementary Table S4. Training and evaluation settings, identical for both models

Setting	Value
Network	2D U-Net, base width 32, 7.76 M parameters
Input channels	9 (baseline U-Net) / 10 (Distance U-Net)
Output classes	background, ventricle, normal WMH, PV, deep
Optimiser	AdamW, learning rate 10^{-4}, weight decay 10^{-5}
Schedule	cosine decay to 10^{-6}; 120 epochs per CV fold
Batch size / precision	8 / automatic mixed precision
Loss	weighted cross-entropy + batch soft Dice, equation (5)
Spatial augmentation	flips, 90° rotations (all channels)
Intensity augmentation	scale 0.9–1.1, shift ±0.1 (MRI channels only)
Model selection	5-fold CV, patient-level pooled lesion Dice
Final model	70 patients, median best epoch (86 / 109)
Inference	flip TTA; minimum component size 0
Random seed	20260911 (+ fold index)
Hardware	NVIDIA RTX 3050 Laptop GPU, 4 GB