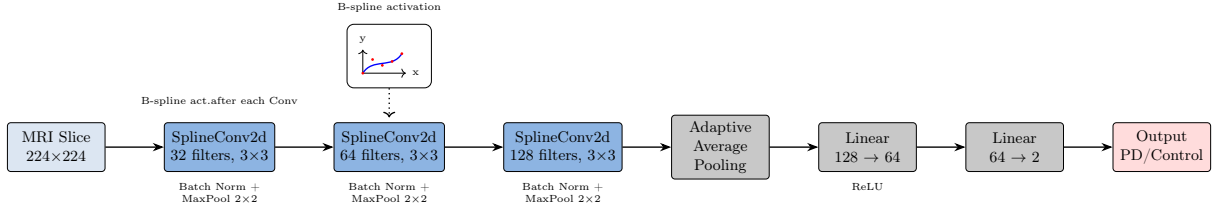


Supplementary Information

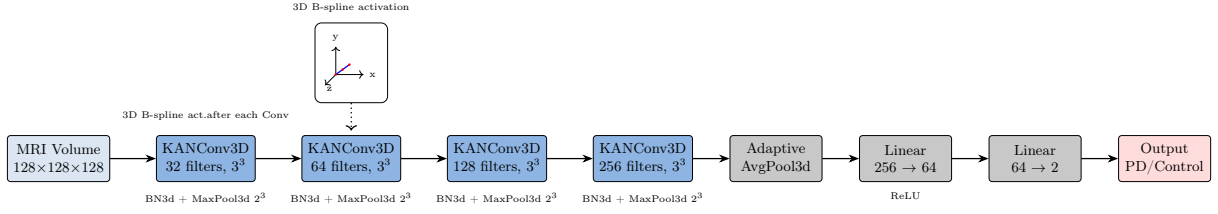
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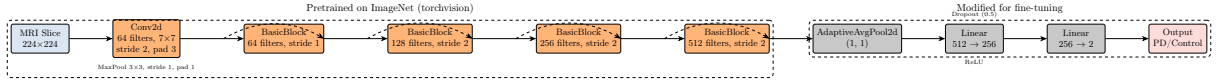
1 Supplementary Figures 1-9: Model Architectures



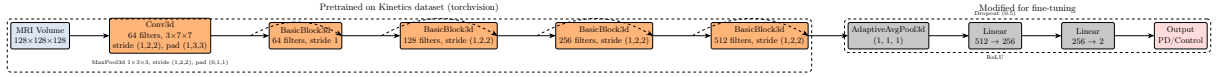
Supplementary Figure 1: Diagram of the ConvKAN 2D Architecture.



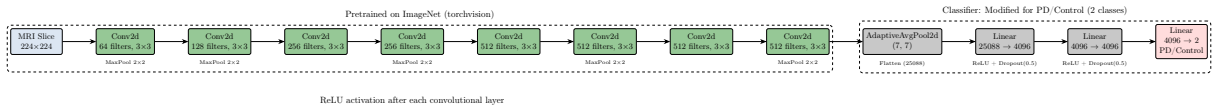
Supplementary Figure 2: Diagram of the ConvKAN 3D Architecture.



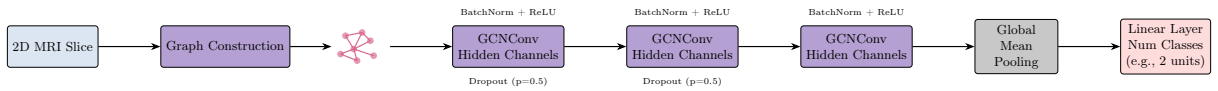
Supplementary Figure 3: Diagram of the ResNet18 (2D) Architecture.



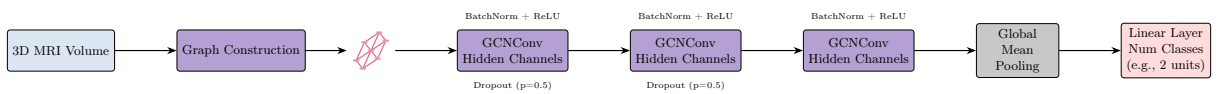
Supplementary Figure 4: Diagram of the ResNet18 (3D) Architecture.



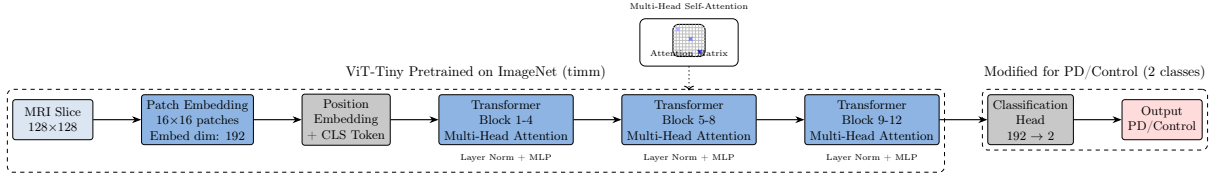
Supplementary Figure 5: Diagram of the VGG11 (2D) Architecture.



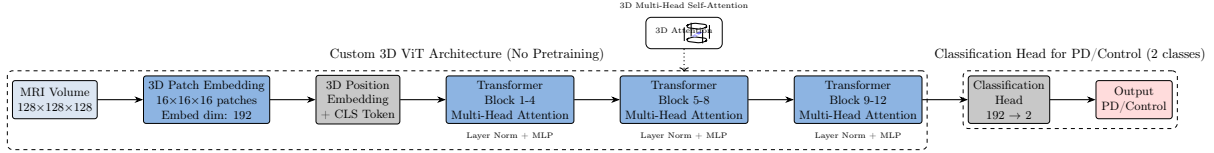
Supplementary Figure 6: Diagram of the GCN (2D) Architecture.



Supplementary Figure 7: Diagram of the GCN (3D) Architecture.



Supplementary Figure 8: Diagram of the Vision Transformer (ViT2D) Architecture.



Supplementary Figure 9: Diagram of the 3D Vision Transformer (ViT3D) Architecture.

2 Supplementary Table 1: Extended Training and Hyperparameter Details

Supplementary Table 1: Training and Hyperparameter Settings.

Parameter Category	Parameter	Value / Setting
Optimizer	Type	Adam
	Initial Learning Rate	1e-4
	Adam β_1	0.9
	Adam β_2	0.999
	Weight Decay	1e-5 (L2 Regularization)
Loss Function	Type	Cross-Entropy
	Label Smoothing	0.1
	Class Weights	Inverse frequency (to handle imbalance)
Training Control	Early Stopping Monitor	Validation Loss
	Early Stopping Patience	15 epochs
	Early Stopping Min Delta	1e-4
	Learning Rate Schedule	Linear Warmup (5 epochs), then Reduce on Plateau
	LR Reduction Factor	0.5
	LR Reduction Patience	10 epochs
Batch Size	Gradient Clipping	Max Norm 1.0
	2D Models	32
Prediction Calibration	3D Models	8
	Calibration Method	Temperature Scaling
Hardware	Initial Temperature (T)	1.5 (refined during validation)
	GPU	NVIDIA A100

3 Supplementary Tables 2-8: Comprehensive Performance Metrics

Supplementary Table 2: Performance Metrics for Isolated Analysis: PPMI Dataset

Model	Dim	AUC (95% CI)	Accuracy (95% CI)	F1 Score (95% CI)	Specificity (95% CI)
ConvKAN	2D	0.973 (0.964-0.981)	0.830 (0.811-0.849)	0.787 (0.766-0.809)	0.846 (0.827-0.865)
GNN	2D	0.849 (0.831-0.867)	0.639 (0.615-0.664)	0.442 (0.417-0.467)	0.844 (0.825-0.863)
ResNet	2D	0.878 (0.862-0.895)	0.723 (0.701-0.746)	0.769 (0.747-0.792)	0.564 (0.538-0.590)
VGG	2D	0.501 (0.476-0.526)	0.516 (0.491-0.541)	0.000 (0.000-0.000)	1.000 (1.000-1.000)
ViT	2D	0.839 (0.821-0.857)	0.749 (0.726-0.772)	0.769 (0.747-0.792)	0.729 (0.705-0.753)
ConvKAN	3D	0.629 (0.355-0.902)	0.583 (0.304-0.862)	0.000 (0.000-0.000)	1.000 (1.000-1.000)
GNN	3D	0.429 (0.149-0.709)	0.417 (0.138-0.696)	0.588 (0.312-0.864)	0.000 (0.000-0.000)
ResNet	3D	0.686 (0.423-0.948)	0.333 (0.067-0.600)	0.500 (0.219-0.781)	0.000 (0.000-0.000)
ViT	3D	0.926 (0.908-0.944)	0.881 (0.858-0.904)	0.885 (0.862-0.908)	0.877 (0.854-0.900)

Supplementary Table 3: Performance Metrics for Isolated Analysis: NEUROCON Dataset

Model	Dim	AUC (95% CI)	Accuracy (95% CI)	F1 Score (95% CI)	Specificity (95% CI)
ConvKAN	2D	0.958 (0.943-0.973)	0.892 (0.869-0.915)	0.913 (0.894-0.932)	0.796 (0.764-0.828)
GNN	2D	0.607 (0.572-0.643)	0.595 (0.559-0.631)	0.746 (0.715-0.777)	0.000 (0.000-0.000)
ResNet	2D	0.553 (0.517-0.590)	0.595 (0.559-0.631)	0.746 (0.715-0.777)	0.000 (0.000-0.000)
VGG	2D	0.500 (0.463-0.537)	0.595 (0.559-0.631)	0.746 (0.715-0.777)	0.000 (0.000-0.000)
ViT	2D	0.648 (0.612-0.684)	0.629 (0.593-0.665)	0.667 (0.632-0.702)	0.583 (0.546-0.620)
ConvKAN	3D	0.722 (0.430-1.015)	0.667 (0.359-0.975)	0.800 (0.571-1.000)	0.000 (0.000-0.000)
GNN	3D	0.667 (0.359-0.975)	0.667 (0.359-0.975)	0.800 (0.571-1.000)	0.000 (0.000-0.000)
ResNet	3D	1.000 (1.000-1.000)	0.667 (0.359-0.975)	0.800 (0.571-1.000)	0.000 (0.000-0.000)
ViT	3D	0.459 (0.423-0.495)	0.629 (0.593-0.665)	0.750 (0.716-0.784)	0.458 (0.421-0.495)

Supplementary Table 4: Performance Metrics for Isolated Analysis: Tao Wu Dataset

Model	Dim	AUC (95% CI)	Accuracy (95% CI)	F1 Score (95% CI)	Specificity (95% CI)
ConvKAN	2D	0.795 (0.770-0.820)	0.692 (0.664-0.721)	0.743 (0.716-0.770)	0.613 (0.581-0.645)
GNN	2D	0.542 (0.511-0.572)	0.538 (0.508-0.569)	0.646 (0.616-0.676)	0.194 (0.168-0.220)
ResNet	2D	0.496 (0.465-0.526)	0.492 (0.462-0.523)	0.000 (0.000-0.000)	1.000 (1.000-1.000)
VGG	2D	0.500 (0.469-0.531)	0.492 (0.462-0.523)	0.000 (0.000-0.000)	1.000 (1.000-1.000)
ViT	2D	0.500 (0.469-0.531)	0.548 (0.518-0.578)	0.667 (0.637-0.697)	0.387 (0.357-0.417)
ConvKAN	3D	0.667 (0.340-0.993)	0.375 (0.040-0.710)	0.545 (0.213-0.878)	0.000 (0.000-0.000)
GNN	3D	0.533 (0.188-0.879)	0.375 (0.040-0.710)	0.545 (0.213-0.878)	0.000 (0.000-0.000)
ResNet	3D	0.267 (-0.040-0.573)	0.625 (0.290-0.960)	0.000 (0.000-0.000)	1.000 (1.000-1.000)
ViT	3D	0.591 (0.264-0.918)	0.500 (0.173-0.827)	0.600 (0.269-0.931)	0.333 (0.006-0.660)

Supplementary Table 5: Performance Metrics for Combined Dataset Analysis

Model	Dim	AUC (95% CI)	Accuracy (95% CI)	Sensitivity (95% CI)	Specificity (95% CI)
ConvKAN	2D	0.817 (0.805-0.830)	0.507 (0.491-0.523)	0.855 (0.843-0.866)	0.666 (0.651-0.682)
GNN	2D	0.670 (0.654-0.685)	0.463 (0.447-0.479)	0.673 (0.658-0.688)	0.614 (0.598-0.630)
ResNet	2D	0.479 (0.463-0.495)	0.477 (0.461-0.493)	0.159 (0.147-0.171)	0.891 (0.881-0.901)
VGG	2D	0.500 (0.484-0.516)	0.532 (0.515-0.548)	1.000 (1.000-1.000)	0.000 (0.000-0.000)
ViT	2D	0.656 (0.616-0.696)	0.620 (0.615-0.624)	0.695 (0.680-0.710)	0.607 (0.592-0.622)
ConvKAN	3D	0.702 (0.535-0.868)	0.448 (0.267-0.629)	0.846 (0.715-0.977)	0.500 (0.318-0.682)
GNN	3D	0.611 (0.433-0.788)	0.517 (0.335-0.699)	0.538 (0.357-0.720)	0.812 (0.670-0.955)
ResNet	3D	0.476 (0.294-0.658)	0.483 (0.301-0.665)	0.923 (0.826-1.000)	0.250 (0.092-0.408)
ViT	3D	0.687 (0.649-0.724)	0.648 (0.599-0.697)	0.732 (0.684-0.780)	0.632 (0.583-0.681)

Supplementary Table 6; Hold-out Analysis Performance: Testing on PPMI Dataset

Model	Dim	AUC (95% CI)	Accuracy (95% CI)	Sensitivity/Specificity
ConvKAN	2D	0.330 (0.316-0.345)	0.484 (0.469-0.499)	0.061/0.882
GNN	2D	0.514 (0.498-0.529)	0.481 (0.465-0.496)	1.000/0.000
ResNet	2D	0.509 (0.494-0.524)	0.522 (0.507-0.537)	0.343/0.694
VGG	2D	0.500 (0.487-0.513)	0.476 (0.463-0.489)	1.000/0.000
ViT	2D	0.435	0.441 (0.426-0.456)	0.343/0.533
ConvKAN	3D	0.600 (0.460-0.740)	0.468 (0.325-0.611)	1.000/0.000
GNN	3D	0.642 (0.505-0.779)	0.468 (0.325-0.611)	1.000/0.000
ResNet	3D	0.395 (0.255-0.534)	0.553 (0.411-0.695)	0.091/0.960
ViT	3D	0.460	0.475 (0.332-0.618)	0.455/0.500

Supplementary Table 7: Hold-out Analysis Performance: Testing on NEUROCON Dataset

Model	Dim	AUC (95% CI)	Accuracy (95% CI)	Sensitivity/Specificity
ConvKAN	2D	0.504 (0.489-0.519)	0.381 (0.366-0.395)	0.059/0.930
GNN	2D	0.486 (0.468-0.504)	0.411 (0.393-0.429)	0.000/1.000
ResNet	2D	0.454 (0.439-0.468)	0.627 (0.613-0.641)	1.000/0.000
VGG	2D	0.500 (0.482-0.518)	0.411 (0.394-0.429)	0.000/1.000
ViT	2D	0.394	0.372 (0.357-0.387)	0.000/1.000
ConvKAN	3D	0.407 (0.241-0.572)	0.382 (0.219-0.546)	0.000/1.000
GNN	3D	0.513 (0.345-0.681)	0.382 (0.219-0.546)	0.000/1.000
ResNet	3D	0.458 (0.290-0.625)	0.382 (0.219-0.546)	0.000/1.000
ViT	3D	0.421	0.488 (0.325-0.651)	0.750/0.000

Supplementary Table 8: Hold-out Analysis Performance: Testing on Tao Wu Dataset

Model	Dim	AUC (95% CI)	Accuracy (95% CI)	Sensitivity/Specificity
ConvKAN	2D	0.650 (0.632-0.668)	0.571 (0.552-0.589)	0.262/0.881
GNN	2D	0.537 (0.521-0.552)	0.500 (0.485-0.516)	0.000/1.000
ResNet	2D	0.535 (0.520-0.550)	0.500 (0.484-0.515)	1.000/0.000
VGG	2D	0.500 (0.485-0.515)	0.500 (0.484-0.515)	1.000/0.000
ViT	2D	0.448	0.448 (0.433-0.463)	0.000/1.000
ConvKAN	3D	0.596 (0.426-0.766)	0.531 (0.358-0.704)	1.000/0.000
GNN	3D	0.576 (0.405-0.748)	0.531 (0.358-0.704)	1.000/0.000
ResNet	3D	0.796 (0.656-0.936)	0.719 (0.563-0.875)	0.762/0.667
ViT	3D	0.573	0.500 (0.327-0.673)	0.500/0.500

4 Supplementary Table 9: Computational Efficiency Metrics

Supplementary Table 9: Computational Efficiency Metrics.

Model	Parameters	Training Time per Epoch (s)	Inference Time per Subject (s)
ConvKAN2D	104 225	10.35	0.346
ResNet2D	11 299 523	372.42	11.286
VGG2D	13 081 026	11.80	0.411
GNN2D	8963	55.88	3.852
ConvKAN3D	20 609	5.28	0.014
ResNet3D	33 152 323	138.77	0.374
GNN3D	175 235	35.40	0.845
ViT2D	5 700 000	31.00	1.034
ViT3D	5 700 000	3157.20	52.620

5 Supplementary Tables 10-13: Full Statistical Comparison Results

Supplementary Table 10: Combined Analysis (All Datasets)

Model 1	Model 2	Metric	p-value	Effect Size	95% CI
ConvKAN2D	ResNet2D	AUC	1.70×10^{-10}	6.39	(6.15, 6.62)
ConvKAN2D	VGG2D	AUC	2.14×10^{-09}	5.99	(5.75, 6.22)
ConvKAN2D	GNN2D	AUC	0.004	2.89	(2.66, 3.13)
ConvKAN2D	ResNet3D	AUC	4.44×10^{-16}	8.15	(7.91, 8.38)
ConvKAN2D	GNN3D	AUC	3.02×10^{-08}	5.54	(5.31, 5.77)
ConvKAN2D	ViT2D	AUC	0.211	-1.25	(-1.48, -1.02)
ConvKAN2D	ViT3D	AUC	0.383	-0.87	(-1.10, -0.64)
ConvKAN3D	ResNet2D	AUC	4.68×10^{-05}	4.07	(3.84, 4.30)
ConvKAN3D	GNN3D	AUC	0.104	1.63	(1.40, 1.86)
ConvKAN3D	ViT2D	AUC	0.002	-3.12	(-3.36, -2.89)
ConvKAN3D	ViT3D	AUC	1.69×10^{-06}	-4.79	(-5.02, -4.55)
ResNet2D	ViT2D	AUC	6.66×10^{-16}	-8.10	(-8.33, -7.87)
ResNet2D	ViT3D	AUC	1.49×10^{-14}	-7.69	(-7.92, -7.46)
ResNet3D	ViT2D	AUC	1.96×10^{-13}	-7.35	(-7.58, -7.12)
ResNet3D	ViT3D	AUC	$< 1.00 \times 10^{-16}$	-9.20	(-9.43, -8.97)
VGG2D	ViT2D	AUC	6.66×10^{-16}	-8.07	(-8.30, -7.83)
VGG2D	ViT3D	AUC	1.89×10^{-14}	-7.66	(-7.89, -7.42)
GNN2D	ViT2D	AUC	1.76×10^{-04}	-3.75	(-3.98, -3.52)
GNN2D	ViT3D	AUC	7.37×10^{-04}	-3.38	(-3.61, -3.14)
GNN3D	ViT2D	AUC	1.54×10^{-06}	-4.81	(-5.04, -4.57)
GNN3D	ViT3D	AUC	7.71×10^{-11}	-6.51	(-6.74, -6.27)
ViT2D	ViT3D	AUC	0.704	0.38	(0.15, 0.61)

Supplementary Table 11: Isolated Analysis (PPMI Dataset)

Model 1	Model 2	Metric	p-value	Effect Size	95% CI
ConvKAN2D	ResNet2D	AUC	0.047	1.98	(1.62, 2.35)
ConvKAN2D	GNN2D	AUC	0.016	2.41	(2.05, 2.77)
ConvKAN2D	VGG2D	AUC	5.61×10^{-12}	6.89	(6.53, 7.25)
ConvKAN2D	ConvKAN3D	AUC	8.52×10^{-05}	3.93	(3.57, 4.29)
ConvKAN2D	GNN3D	AUC	5.36×10^{-11}	6.56	(6.20, 6.92)
ConvKAN2D	ResNet3D	AUC	0.001	3.24	(2.88, 3.60)
ConvKAN2D	ViT2D	AUC	0.248	-1.16	(-1.52, -0.80)
ConvKAN2D	ViT3D	AUC	0.161	-1.40	(-1.76, -1.04)
ConvKAN3D	ViT2D	AUC	3.56×10^{-09}	-5.90	(-6.26, -5.54)
ConvKAN3D	ViT3D	AUC	3.56×10^{-09}	-5.90	(-6.26, -5.54)
ResNet2D	ViT2D	AUC	0.031	-2.16	(-2.52, -1.80)
ResNet2D	ViT3D	AUC	0.020	-2.32	(-2.69, -1.96)
GNN2D	ViT2D	AUC	0.002	-3.08	(-3.44, -2.72)
GNN2D	ViT3D	AUC	0.001	-3.22	(-3.58, -2.86)
VGG2D	ViT2D	AUC	4.09×10^{-14}	-7.56	(-7.92, -7.20)
VGG2D	ViT3D	AUC	1.60×10^{-14}	-7.68	(-8.04, -7.32)
GNN3D	ViT2D	AUC	$< 1.00 \times 10^{-16}$	-8.87	(-9.23, -8.51)
GNN3D	ViT3D	AUC	$< 1.00 \times 10^{-16}$	-8.87	(-9.23, -8.51)
ResNet3D	ViT2D	AUC	2.00×10^{-07}	-5.20	(-5.56, -4.84)
ResNet3D	ViT3D	AUC	2.00×10^{-07}	-5.20	(-5.56, -4.84)
ViT2D	ViT3D	AUC	0.626	-0.49	(-0.85, -0.13)

Supplementary Table 12: Isolated Analysis (Neurocon Dataset)

Model 1	Model 2	Metric	p-value	Effect Size	95% CI
ConvKAN2D	ResNet2D	AUC	1.49×10^{-06}	4.81	(4.39, 5.24)
ConvKAN2D	GNN2D	AUC	6.54×10^{-06}	4.51	(4.09, 4.93)
ConvKAN2D	VGG2D	AUC	7.33×10^{-07}	4.95	(4.53, 5.38)
ConvKAN2D	ConvKAN3D	AUC	4.78×10^{-05}	4.07	(3.64, 4.49)
ConvKAN2D	GNN3D	AUC	3.55×10^{-06}	4.64	(4.21, 5.06)
ConvKAN2D	ResNet3D	AUC	1.000	0.00	(0.00, 0.00)
ConvKAN2D	ViT2D	AUC	0.272	1.10	(0.68, 1.52)
ConvKAN2D	ViT3D	AUC	3.97×10^{-05}	4.11	(3.69, 4.53)
ConvKAN3D	ViT2D	AUC	0.575	0.56	(0.14, 0.98)
ConvKAN3D	ViT3D	AUC	0.102	1.63	(1.21, 2.06)
ResNet2D	ViT2D	AUC	2.18×10^{-05}	-4.25	(-4.67, -3.82)
ResNet2D	ViT3D	AUC	0.284	-1.07	(-1.49, -0.65)
GNN2D	ViT2D	AUC	3.69×10^{-05}	-4.13	(-4.55, -3.70)
GNN2D	ViT3D	AUC	0.333	-0.97	(-1.39, -0.55)
VGG2D	ViT2D	AUC	1.51×10^{-05}	-4.33	(-4.75, -3.91)
VGG2D	ViT3D	AUC	0.254	-1.14	(-1.56, -0.72)
GNN3D	ViT2D	AUC	1.000	0.00	(-0.42, 0.42)
GNN3D	ViT3D	AUC	0.288	1.06	(0.64, 1.49)
ResNet3D	ViT2D	AUC	3.55×10^{-06}	4.64	(4.21, 5.06)
ResNet3D	ViT3D	AUC	4.52×10^{-09}	5.86	(5.44, 6.29)
ViT2D	ViT3D	AUC	0.002	3.05	(2.62, 3.47)

Supplementary Table 13: Isolated Analysis (TaoWu Dataset)

Model 1	Model 2	Metric	p-value	Effect Size	95% CI
ConvKAN2D	ResNet2D	AUC	0.003	2.94	(2.51, 3.38)
ConvKAN2D	GNN2D	AUC	0.012	2.50	(2.06, 2.94)
ConvKAN2D	VGG2D	AUC	0.004	2.90	(2.46, 3.34)
ConvKAN2D	ConvKAN3D	AUC	1.000	0.00	(-0.44, 0.44)
ConvKAN2D	GNN3D	AUC	0.219	1.23	(0.79, 1.67)
ConvKAN2D	ResNet3D	AUC	9.11×10^{-05}	3.91	(3.47, 4.35)
ConvKAN2D	ViT2D	AUC	0.034	2.12	(1.68, 2.55)
ConvKAN2D	ViT3D	AUC	0.864	-0.17	(-0.61, 0.27)
ConvKAN3D	ViT2D	AUC	0.535	0.62	(0.18, 1.06)
ConvKAN3D	ViT3D	AUC	0.002	-3.16	(-3.60, -2.72)
ResNet2D	ViT2D	AUC	0.684	-0.41	(-0.85, 0.03)
ResNet2D	ViT3D	AUC	0.006	-2.73	(-3.17, -2.29)
GNN2D	ViT2D	AUC	0.769	0.29	(-0.14, 0.73)
GNN2D	ViT3D	AUC	0.047	-1.99	(-2.42, -1.55)
VGG2D	ViT2D	AUC	0.436	-0.78	(-1.22, -0.34)
VGG2D	ViT3D	AUC	0.002	-3.13	(-3.57, -2.70)
GNN3D	ViT2D	AUC	0.547	-0.60	(-1.04, -0.16)
GNN3D	ViT3D	AUC	5.77×10^{-06}	-4.53	(-4.97, -4.10)
ResNet3D	ViT2D	AUC	0.001	-3.19	(-3.63, -2.76)
ResNet3D	ViT3D	AUC	$< 1.00 \times 10^{-16}$	-8.30	(-8.74, -7.86)
ViT2D	ViT3D	AUC	0.022	-2.29	(-2.73, -1.85)

6 Supplementary Methods: Confidence-Weighted Voting System Details

The slice-level aggregation algorithm follows as such:

1. **Confidence Calculation:** For each slice prediction, we calculated confidence as the distance from the decision boundary (0.5):

$$w_{\text{raw}} = |p_i - 0.5| \quad (1)$$

where p_i is the predicted probability for the positive class (PD) for slice i .

2. **Exponential Weighting:** We applied exponential weighting to emphasize high-confidence predictions:

$$w_i = e^{w_{\text{raw}}} - 1 \quad (2)$$

This exponential transformation significantly amplified the influence of predictions far from the decision boundary.

3. **Slice Selection:** We selected the top 33% most confident slices based on these weights:

$$\text{top_indices} = \text{argsort}(w)[-(n \cdot 0.33) :] \quad (3)$$

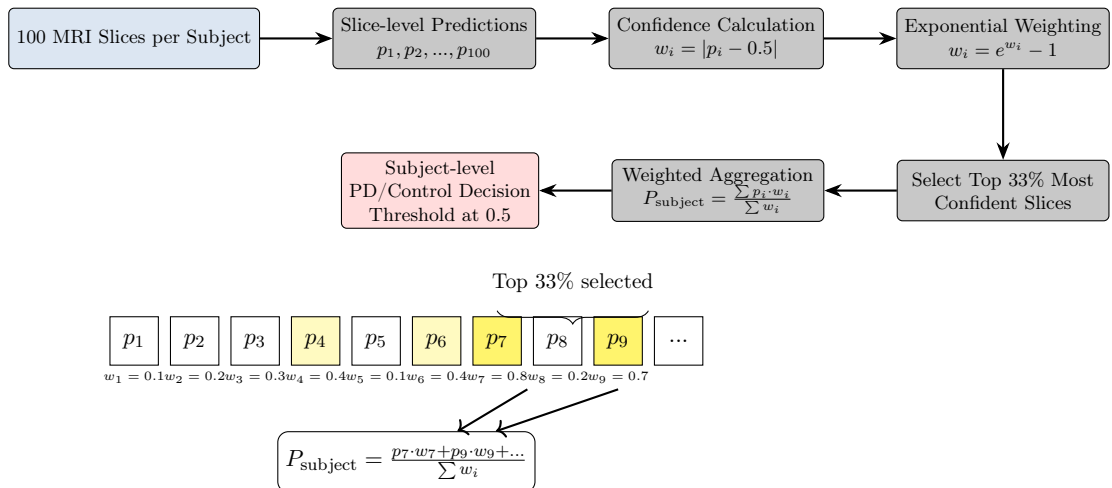
where n is the total number of slices.

4. **Weighted Aggregation:** The final subject-level probability was calculated as:

$$P_{\text{subject}} = \frac{\sum_{i \in \text{top_indices}} p_i \cdot w_i}{\sum_{i \in \text{top_indices}} w_i} \quad (4)$$

5. **Final Classification:** The subject-level binary classification was determined by thresholding at 0.5:

$$y_{\text{subject}} = \begin{cases} 1 & \text{if } P_{\text{subject}} > 0.5 \\ 0 & \text{otherwise} \end{cases} \quad (5)$$



Supplementary Figure 10: Illustration of the confidence-weighted voting system for aggregating slice-level predictions to subject-level classifications. The system selects the top 33% most confident slice predictions, applies exponential weighting based on confidence scores, and computes a weighted average for the final subject-level probability.