PRA-PoE

Robust Multimodal Alzheimer's Disease Classification under Arbitrary Modality Missingness

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Code & resources
MICCAI 2026
Oral presentation

Inputs and clinical motivation

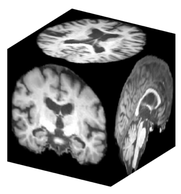
Research problem

Changing observed subsets shift representations.

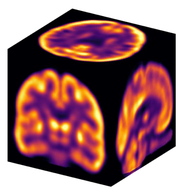
Uncertain completed features can distort fusion.

Age / education
Cognitive measures
APOE4 / demographics

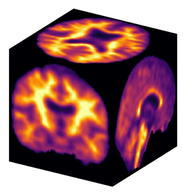
Tabular data



T1



FDG-PET

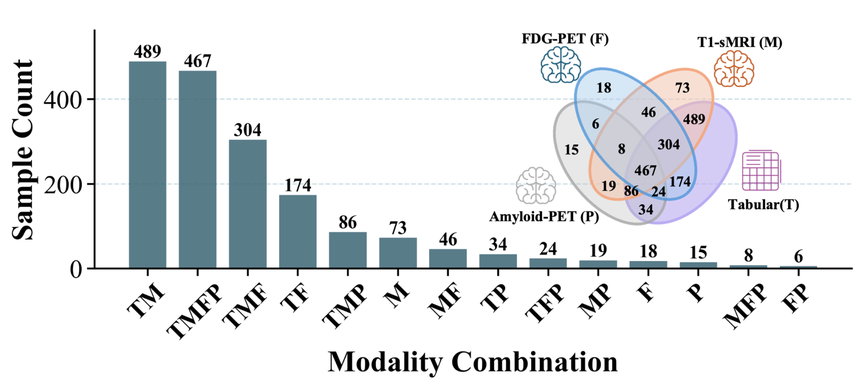


Amyloid-PET

Supervised classification

Tabular MLP + 3D image encoders
ADNI: CN / MCI / AD
OASIS-3: CN / AD

Missingness and evaluation design

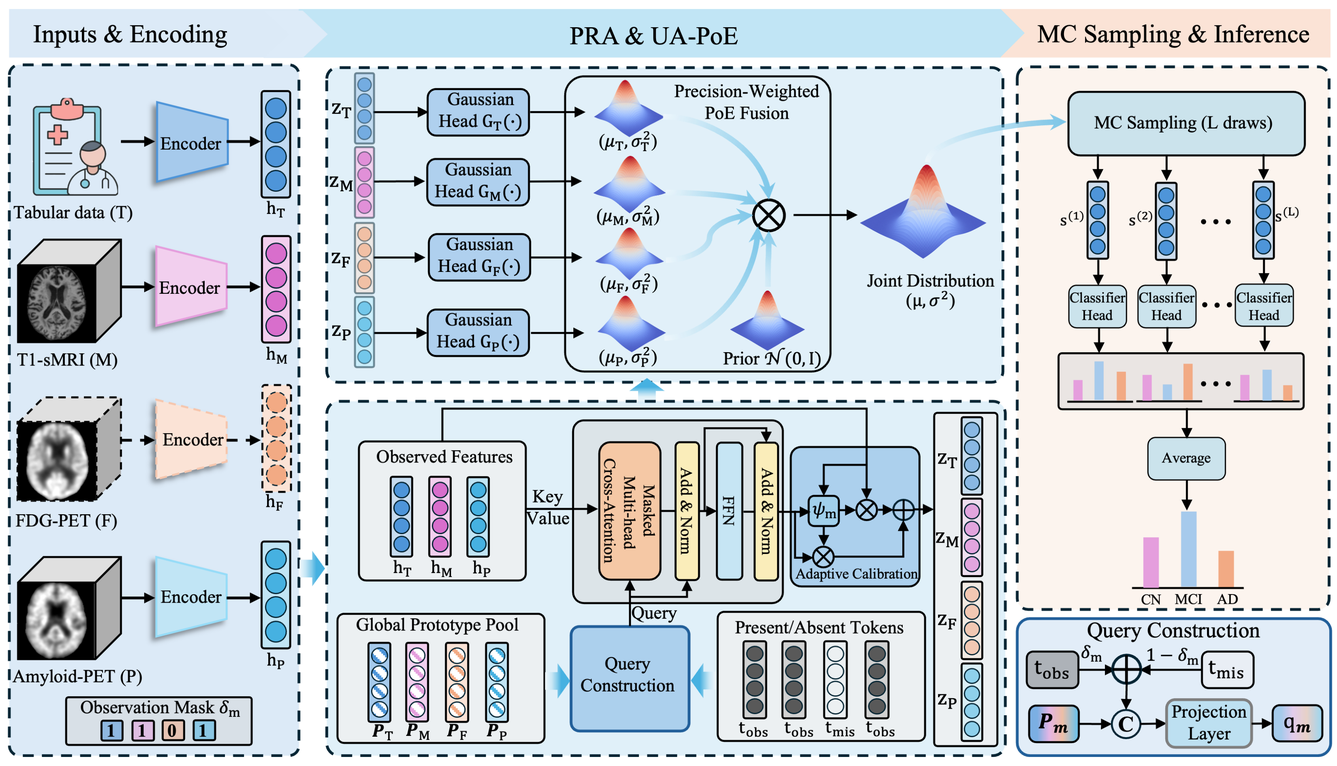


Natural missingness → all-subset test

Train on incomplete inputs. Evaluate complete test subjects under all **15 non-empty subsets**; three seeds.

Cohort	Train	Val	Test
ADNI	1,504	259	471
OASIS-3	757	127	104

PRA alignment and uncertainty-aware fusion



Main results: complete baseline comparison

Method	ADNI · CN / MCI / AD ↑			OASIS-3 · CN / AD ↑			Computational cost		
Method	**ACC**	**AUC**	**Macro-F1**	**ACC**	**AUC**	**AD F1**	**Params (M)**	**FLOPs (G)**	**ms/sample**
mmFormer	51.7 (2.1)	68.4 (1.1)	44.6 (2.6)	86.8 (2.1)	72.8 (6.2)	40.3 (12.2)	26.4	65.2	31.7
ShaSpec	56.9 (1.9)	73.6 (1.4)	54.1 (1.0)	87.7 (0.0)	88.2 (2.4)	51.0 (13.5)	144.1	482.4	43.9
AnyMod	59.7 (1.1)	76.6 (1.3)	56.8 (3.6)	85.5 (1.6)	82.3 (4.8)	51.5 (4.5)	11.9	92.4	129.8
M3Care	59.7 (1.1)	78.7 (1.5)	59.9 (2.0)	88.5 (1.7)	88.7 (0.7)	52.9 (6.2)	19.2	18.4	11.9
FuseMoE	58.5 (1.2)	77.6 (0.3)	57.0 (2.0)	88.9 (1.7)	86.6 (1.3)	57.7 (5.9)	118.8	18.5	2.5
Flex-MoE	57.1 (1.7)	74.3 (1.4)	48.1 (2.5)	88.7 (2.3)	87.5 (1.0)	57.3 (7.0)	13.8	18.4	28.0
MoE-retriever	60.6 (3.1)	78.3 (1.9)	57.5 (2.6)	89.8 (0.3)	86.4 (1.9)	58.0 (2.8)	15.1	18.4	74.2
PRA-PoE	**63.9** (0.4)	**81.4** (0.3)	**61.7** (0.8)	**90.3** (0.6)	**89.5** (0.5)	**64.3** (0.9)	13.8	18.4	8.1

Mean (SD), three seeds, all 15 subsets. Bold: best displayed performance mean; teal: PRA-PoE. Timing follows the paper's profiling setup.

ADNI: accuracy across clinical modality combinations

Observed subset	mmFormer	ShaSpec	AnyMod	M3Care	FuseMoE	Flex-MoE	MoE-retr.	PRA-PoE
Tab	56.8 (5.0)	**67.9** (3.5)	64.2 (2.4)	60.3 (2.9)	63.6 (2.5)	65.2 (3.3)	61.3 (7.6)	65.3 (0.5)
Tab + T1	56.3 (4.0)	56.3 (3.7)	64.8 (1.8)	63.4 (5.4)	61.1 (4.6)	64.8 (2.3)	63.7 (7.5)	**68.7** (1.6)
Tab + FDG	60.6 (2.0)	59.9 (1.7)	67.4 (0.5)	65.6 (1.1)	68.0 (0.9)	69.1 (0.7)	65.0 (2.6)	**70.1** (0.5)
Tab + Amy	53.3 (2.8)	58.5 (3.3)	65.9 (0.6)	61.1 (3.3)	59.7 (3.1)	62.1 (2.3)	62.0 (6.2)	**68.4** (0.5)
Tab + T1 + FDG	60.2 (1.8)	60.7 (1.9)	66.8 (1.0)	66.7 (2.7)	68.3 (1.2)	**70.3** (0.4)	67.3 (2.1)	69.5 (1.2)
Tab + T1 + Amy	53.8 (3.0)	57.7 (4.6)	66.2 (0.6)	64.1 (4.4)	60.4 (5.4)	66.0 (3.4)	64.0 (5.0)	**69.1** (0.8)
Tab + FDG + Amy	59.9 (2.1)	61.7 (3.3)	67.3 (0.8)	65.7 (1.3)	69.4 (1.5)	69.8 (0.8)	69.3 (2.1)	**71.9** (2.1)
All four	61.0 (1.9)	60.7 (3.6)	66.9 (1.4)	65.8 (2.8)	68.8 (1.8)	69.5 (0.1)	69.0 (4.0)	**72.1** (0.8)
8-subset mean	57.7 (2.7)	60.4 (2.5)	66.2 (1.0)	64.1 (0.7)	64.9 (1.2)	67.1 (1.2)	65.2 (4.1)	**69.4** (1.3)

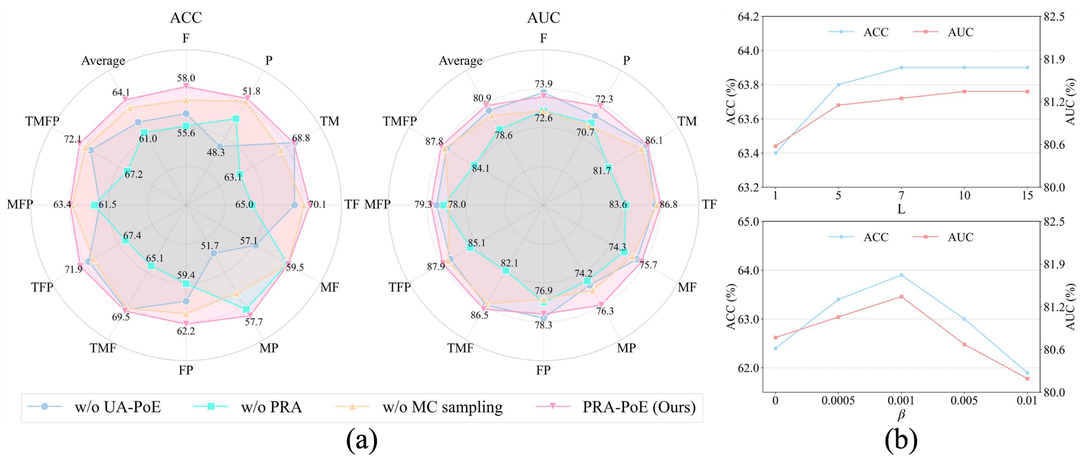
ACC (%), mean (SD), eight tabular-containing subsets. Tab: clinical variables; Amy: amyloid-PET. This mean differs from the 15-subset main result.

OASIS-3: accuracy across clinical modality combinations

Observed subset	mmFormer	ShaSpec	AnyMod	M3Care	FuseMoE	Flex-MoE	MoE-retr.	PRA-PoE
Tab	85.6 (1.7)	86.5 (6.7)	**90.4** (1.0)	89.7 (2.8)	89.4 (1.0)	88.5 (1.0)	89.1 (2.1)	**90.4** (1.9)
Tab + T1	85.6 (3.5)	89.4 (1.0)	86.2 (1.5)	87.5 (3.3)	88.8 (1.5)	85.3 (4.5)	90.7 (2.4)	**91.7** (1.1)
Tab + FLAIR	82.7 (2.5)	84.3 (2.4)	84.6 (2.9)	86.2 (2.4)	85.3 (4.5)	88.1 (2.8)	86.5 (1.9)	**89.7** (0.6)
Tab + Amy	87.5 (4.4)	90.4 (1.0)	90.4 (3.3)	89.1 (3.1)	**92.9** (0.6)	91.3 (1.7)	90.4 (1.7)	**92.9** (2.2)
Tab + T1 + FLAIR	86.5 (1.0)	87.8 (1.5)	84.3 (1.5)	87.8 (2.0)	87.8 (2.9)	86.2 (3.6)	**92.3** (1.7)	91.3 (1.0)
Tab + T1 + Amy	88.8 (3.1)	90.7 (2.0)	89.7 (3.6)	90.4 (2.5)	**92.6** (1.5)	89.7 (1.5)	92.3 (1.0)	92.0 (0.6)
Tab + FLAIR + Amy	88.5 (1.0)	87.5 (1.9)	87.5 (5.4)	90.7 (1.1)	90.7 (2.4)	92.0 (2.2)	92.3 (0.0)	**92.9** (1.1)
All four	88.5 (1.7)	88.5 (1.0)	88.1 (4.9)	90.1 (2.0)	90.1 (2.4)	89.7 (3.6)	93.3 (1.0)	**93.6** (0.6)
8-subset mean	86.7 (2.2)	88.1 (0.3)	87.7 (2.7)	88.9 (1.7)	89.7 (1.4)	88.9 (2.1)	90.9 (0.8)	**91.8** (0.8)

ACC (%), mean (SD), eight tabular-containing subsets. OASIS-3 inputs: Tab / T1 / FLAIR / amyloid-PET; this is a cohort-specific configuration.

Subset ablation and sensitivity



Component contributions

Variant	ADNI ACC
Without PRA	61.0
Without UA-PoE	62.2
PRA-PoE (full)	64.1

Separate ablation; main-table ACC is 63.9%.

MC draws: performance saturates near 10.
KL weight: selected β = 0.001.

Contributions: availability-conditioned feature alignment; precision-weighted fusion retaining all four experts.

Scope: retrospective cohort evidence; prospective clinical utility remains to be established. FDG: Nespral Torres et al., Zenodo 20553851 (CC BY 4.0); external template illustration.