Energy-induced Explicit quantification for Multi-modality MRI fusion

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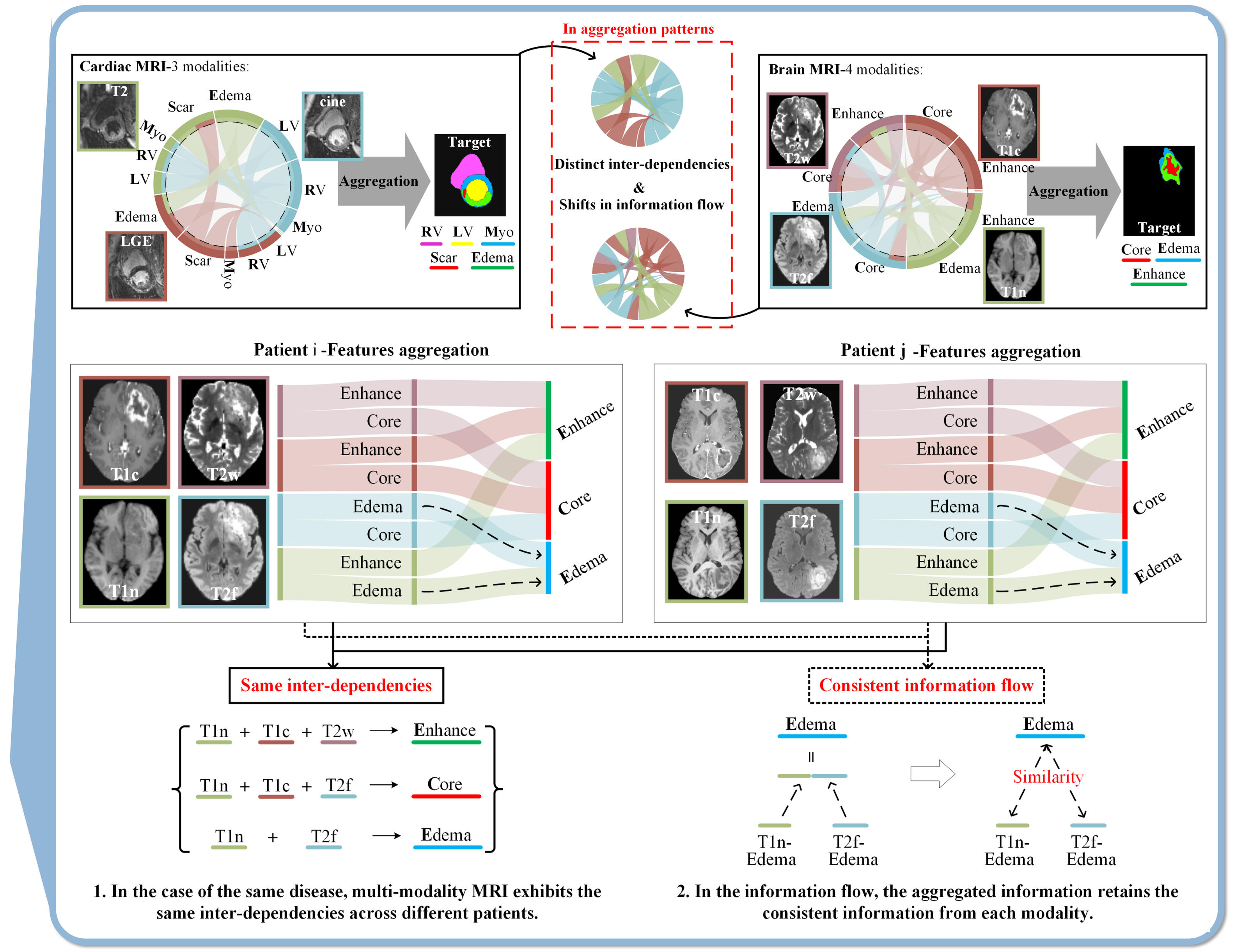
Energy model-based aggregation prototype explicitly quantifies aggregation from the inter-dependencies and information flow

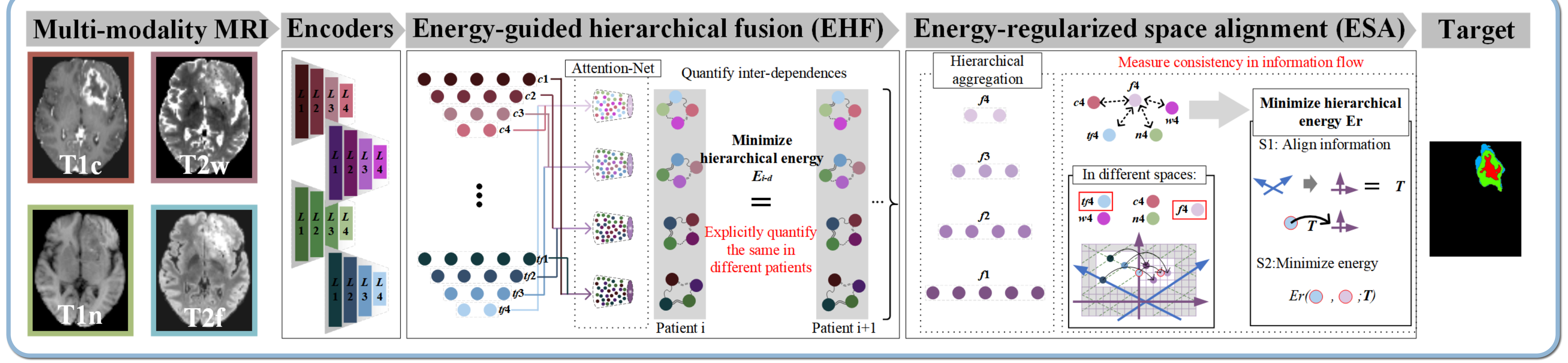


Target: Explicitly quantify and optimize the properties of multi-modality MRI fusion to adapt to different scenarios.

Challenge: The information aggregation of multi-modality MRI follows a pipeline where information from different modalities flows in accordance with their inter-dependencies. It can be found that the aggregations of different diseases rely on distinct inter-dependencies and shifts in information flow among modalities. Due to the different inter-dependencies and information flow in various aggregations, a unified aggregation pattern is difficult to define for the diseases in various scenarios.

Contribution:

- E^2PA explicitly quantifies aggregation from the inter-dependencies and information flow by the energy model. This fundamental property-based multi-modality aggregation pattern is adaptive to different medical scenarios directly and greatly boosts the performance of downstream diagnostic tasks.
- EHF establishes an equivalence between the measurement of inter-dependencies and the optimization of the energy to the aggregation.
- ESA identifies a provable theory that guarantees the consistency of information in multi-modality aggregation.



Experiments: We evaluate E^2PA on various multi-modality MRI scenarios, including: cardiac pathology segmentation (MyoPS dataset), brain tumor segmentation (BraTS2021 dataset), and detection of anterior cruciate ligament tears (MRNet dataset).

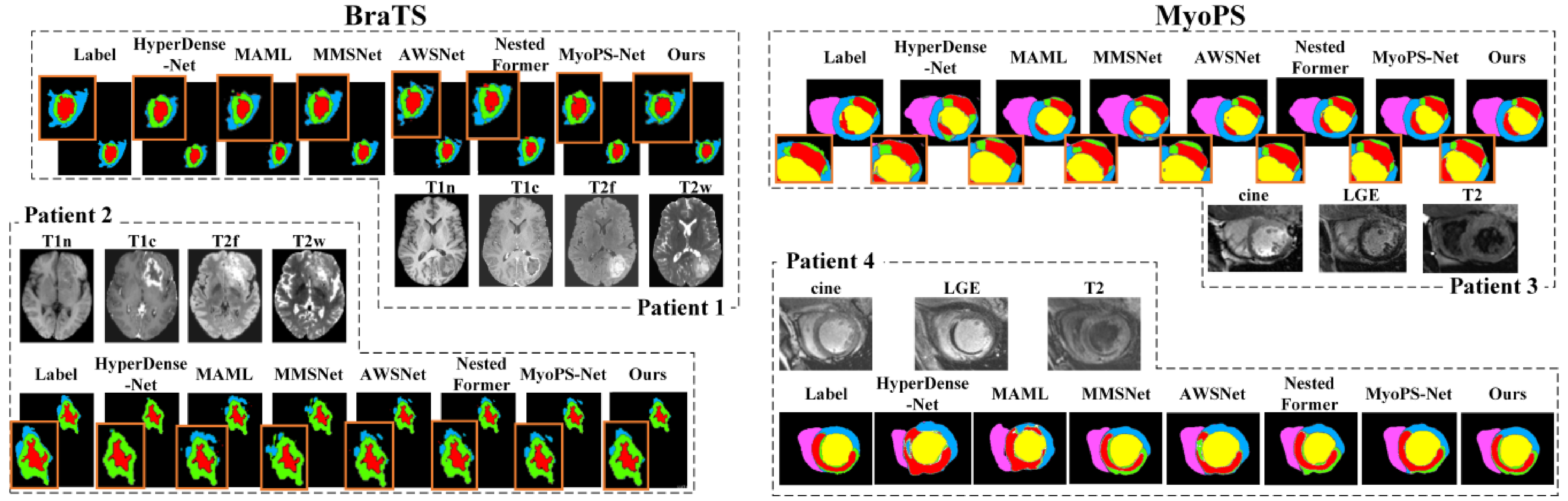
Data details: The details of multi-modality MRI scenarios.

Name	Modality	Target	Train	Test	Total
MyoPS	cine,LGE,T2	Seg	15	10	25
BraTS	T1c, T1n, T2f, T2w	Seg	834	417	1251
MRNet	Sagittal T2,Axial PD, Coronal T1	Class	753	377	1130

Result 1: Evaluations on BraTS and MyoPS datasets.

Methods	BraTS%				MyoPS%					
	TC	ET	WT	AVG	scar	edema	LV	RV	MYO	AVG
HyperDense-Net	84.1	80.3	87.1	83.8	57.3	68.6	93.1	87.8	77.9	76.9
MAML	86.9	85.4	89.9	87.4	61.1	70.9	93.3	89.9	79.3	78.9
MMSNet	83.3	82.1	88.4	84.6	60.5	73.6	94.1	89.3	83.8	80.3
AWSNet	87.0	86.6	92.8	88.8	61.1	72.3	92.8	88.2	81.4	79.2
NestedFormer	88.4	85.1	91.3	88.3	62.0	73.1	93.9	89.9	84.7	80.7
MyoPS-Net	90.1	81.1	89.3	86.8	63.4	**74.0**	94.0	**92.0**	86.1	81.9
Ours	**91.0**	**87.3**	**93.5**	**90.6**	**64.7**	73.9	**94.4**	91.1	**87.0**	**82.2**

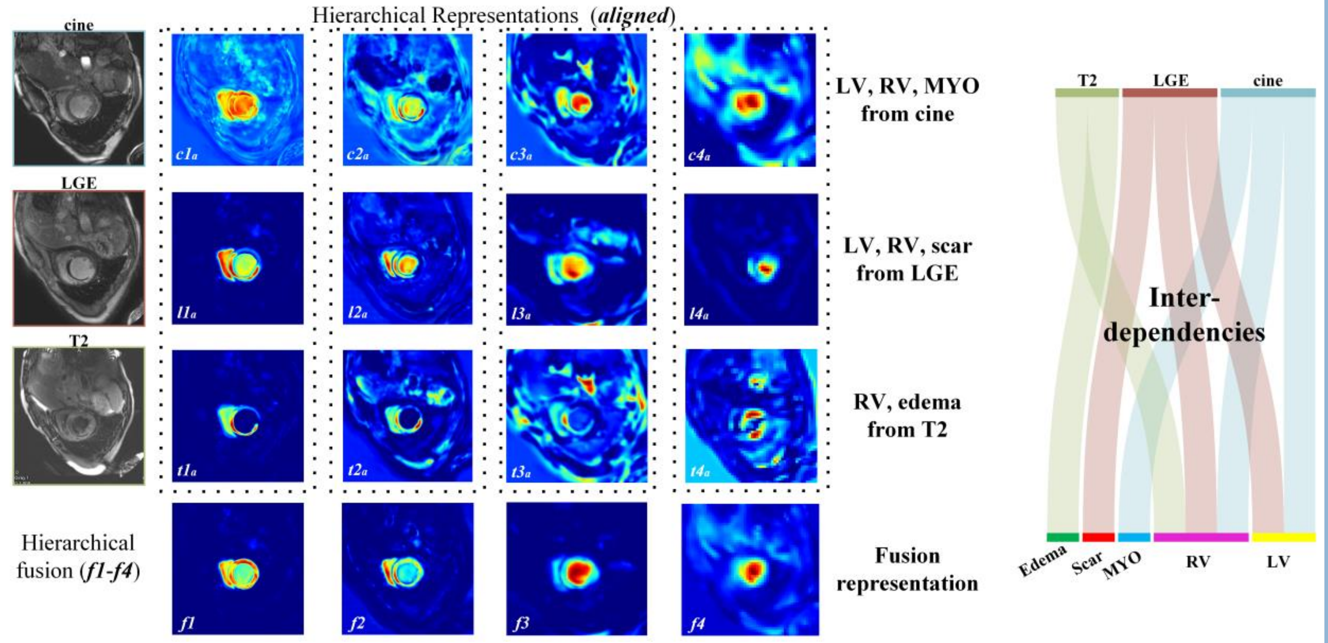
Result 2: Our proposed framework has powerful visual superiority.



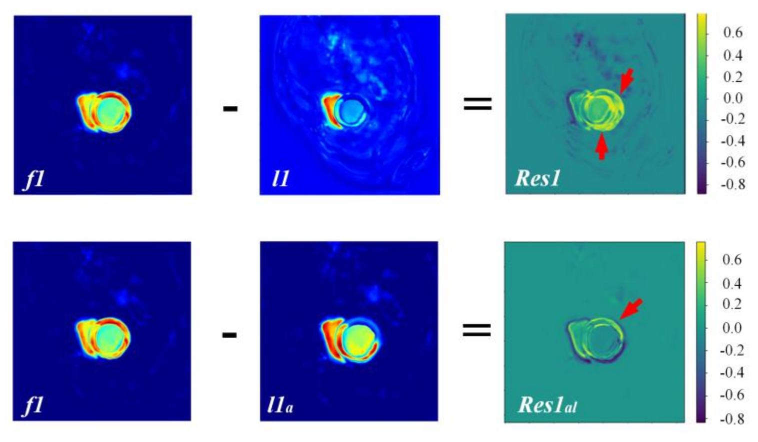
Result 3: Evaluations on MRNet dataset.

AUC	MRNet	ELNet	MRPyrNet (MRNet)	MRPyrNet (ELNet)	TransMed	**Ours**
Abn	93.0%	93.7%	93.1%	94.0%	95.8%	**97.8%**
ACL	95.1%	94.9%	96.0%	95.7%	96.3%	**97.5%**
Men	83.3%	86.8%	89.3%	89.1%	92.3%	**94.4%**

Result 4: The quantification of inter-dependencies.



Result 5: The residual reveals the consistency of information flow in aggregation, and the essential alignment



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