MCF: Mutual Correction Framework for Semi-Supervised Medical Image Segmentation

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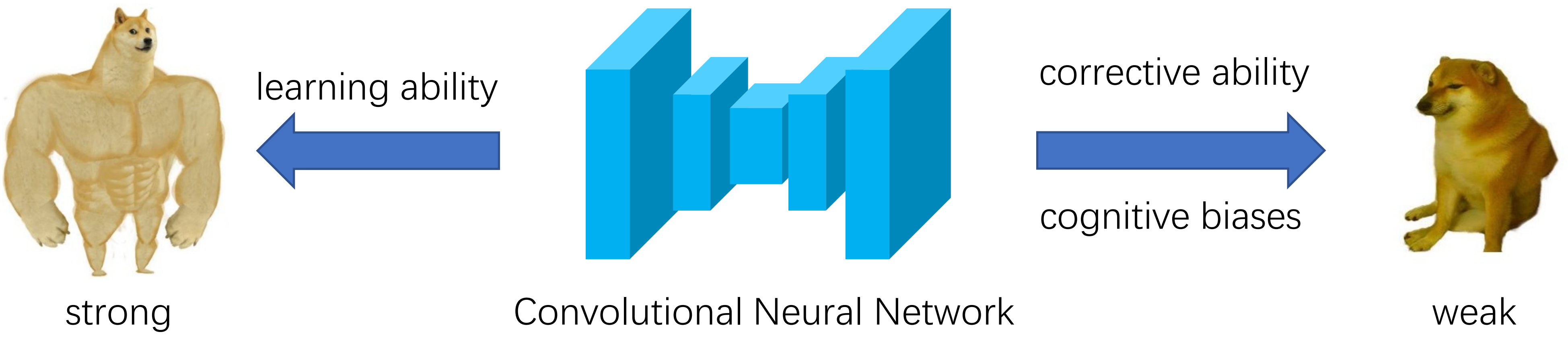
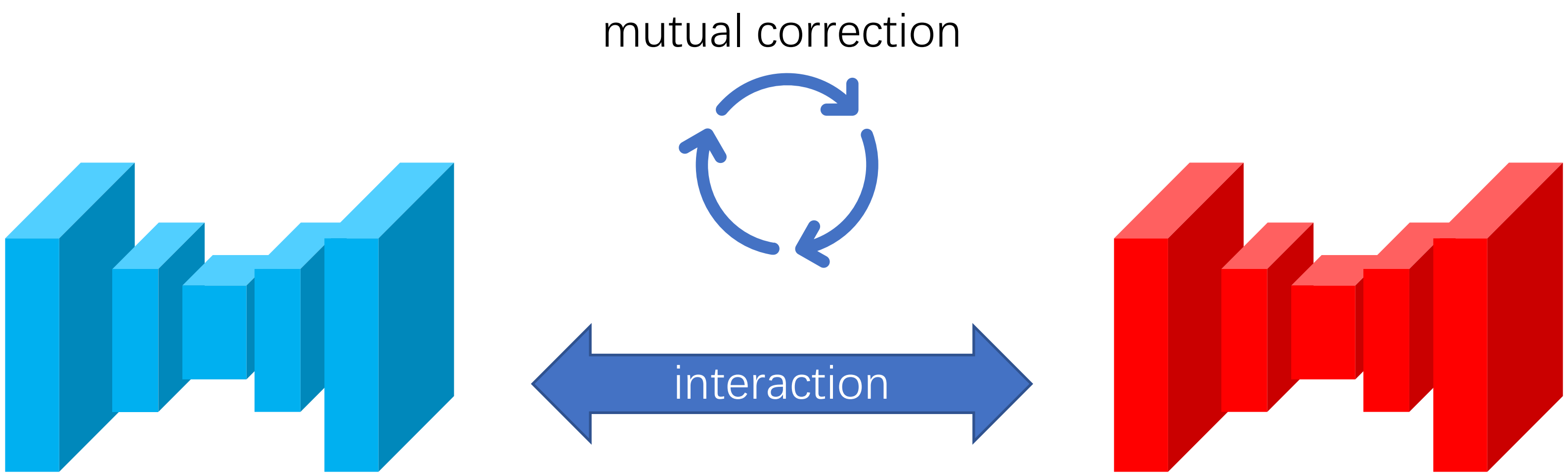
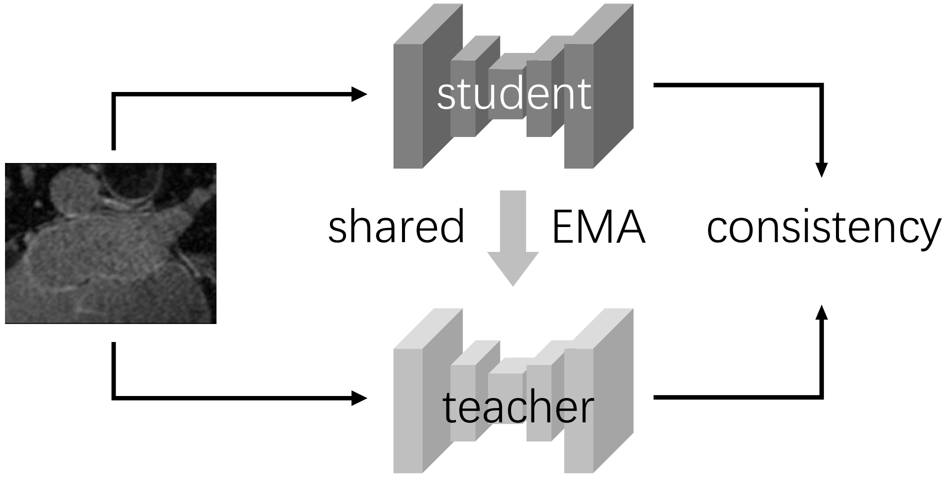
Poster : WED-PM-314

Overview


learning ability
corrective ability
cognitive biases
strong
Convolutional Neural Network
weak


mutual correction
interaction

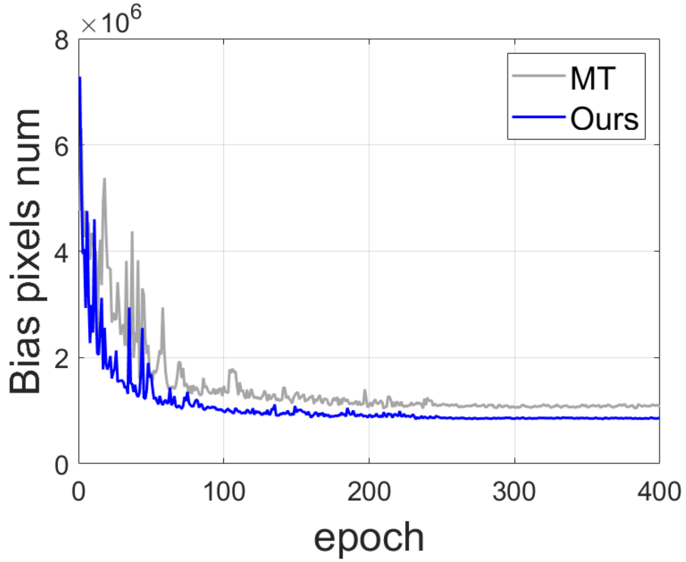
Cognitive biases in MT based methods

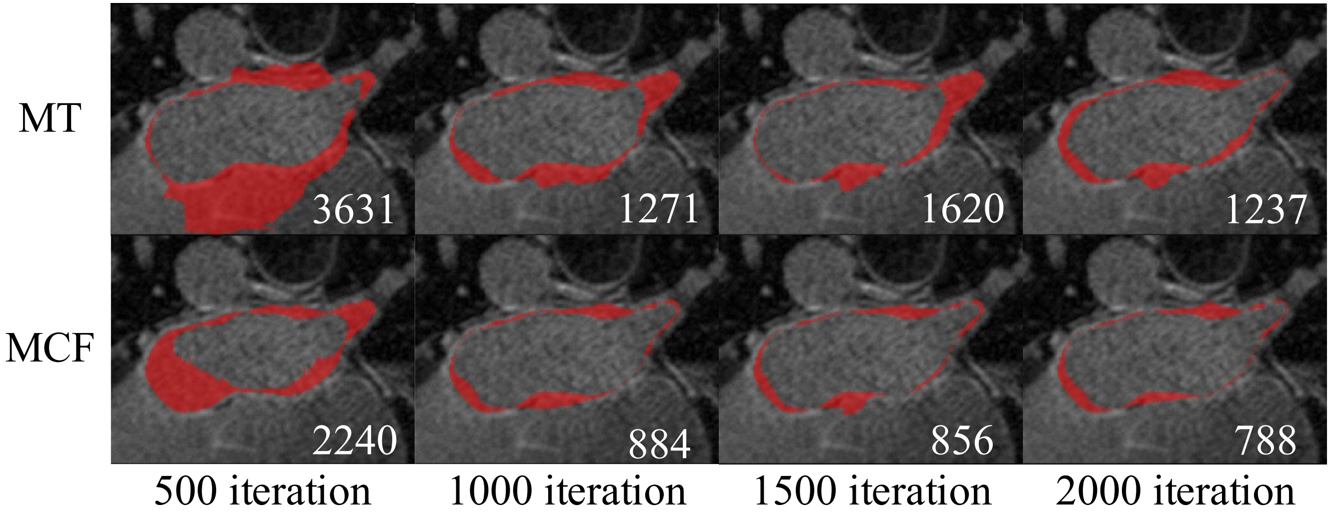


MT-like method

shortcoming				benefit
reduces model diversity	←	shared structure	}	consistent predictions
performance limitations	←	EMA parameter update	}	
biased Pseudo-Labeling	←	consistency regularization	→	supervised on unlabeled data

Cognitive biases in MT based methods

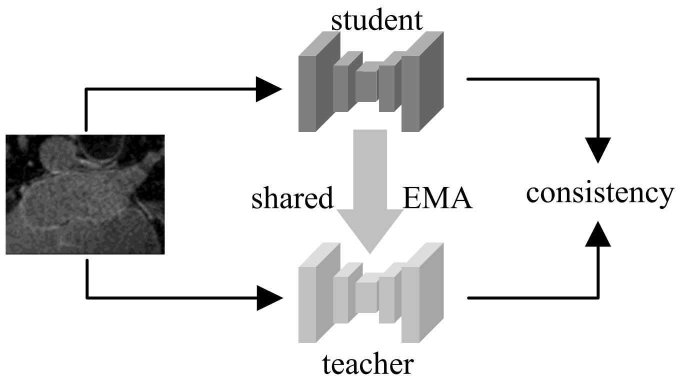


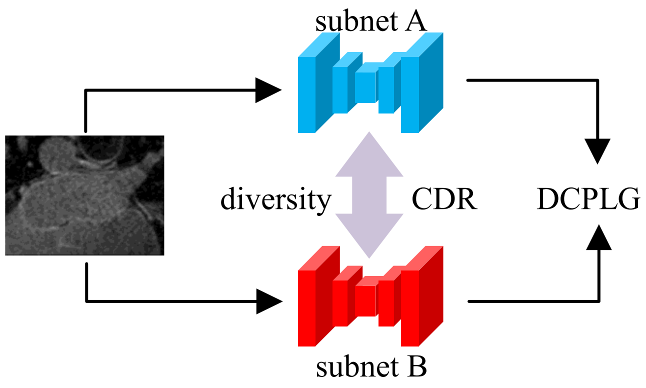


Cognitive bias is the phenomenon in which the model persists in mispredictions, caused by overfitting to wrong supervision signals [1].

[1] Liu F, Tian Y, Chen Y, et al. ACPL: Anti-curriculum pseudo-labelling for semi-supervised medical image classification[C]//Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition. 2022: 20697-20706.

Mutual Correction Framework



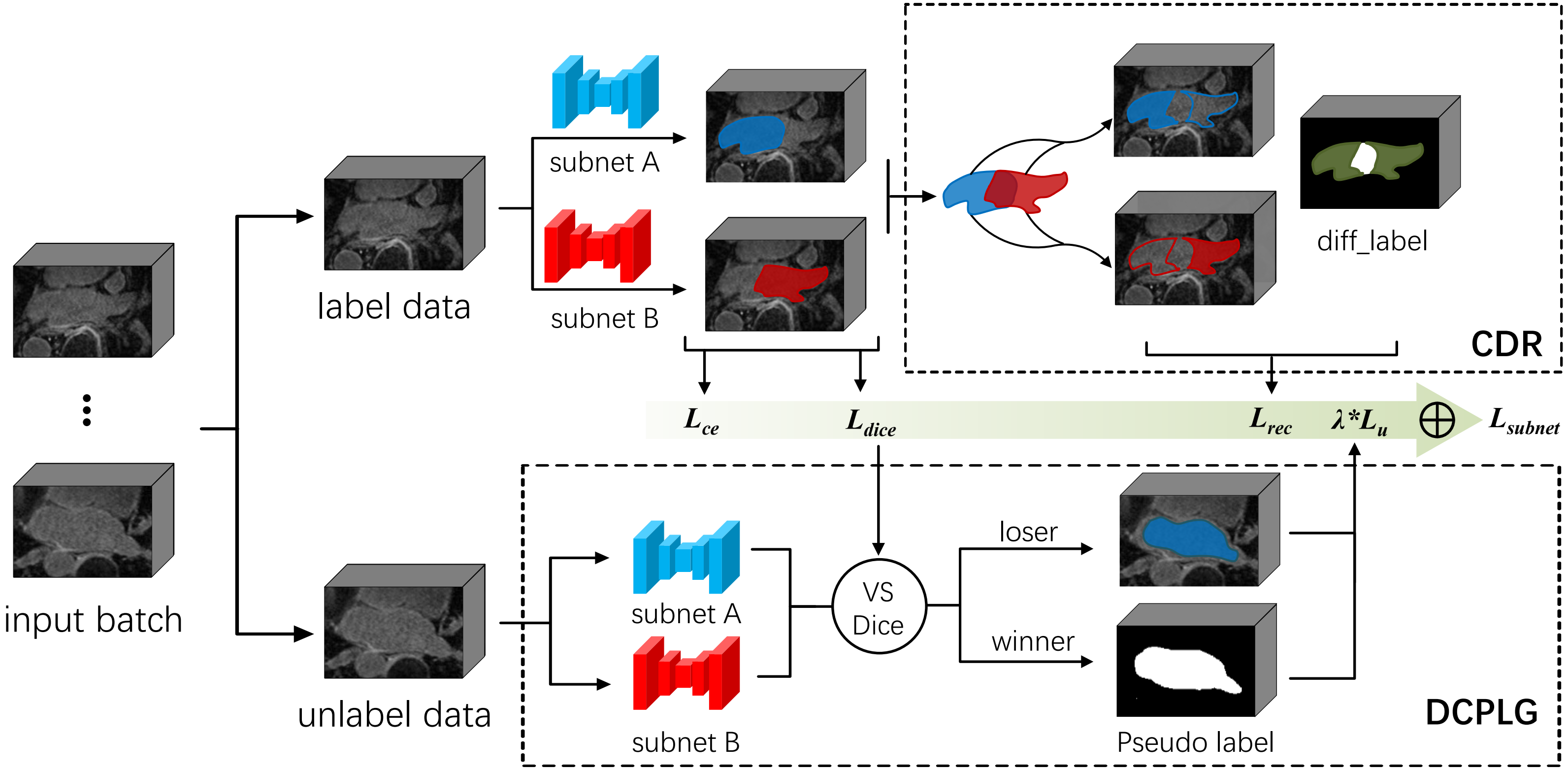


shared structure → different structure

EMA parameter update → independent parameter update

consistency regularization → dynamic pseudo-label generation

Mutual Correction Framework

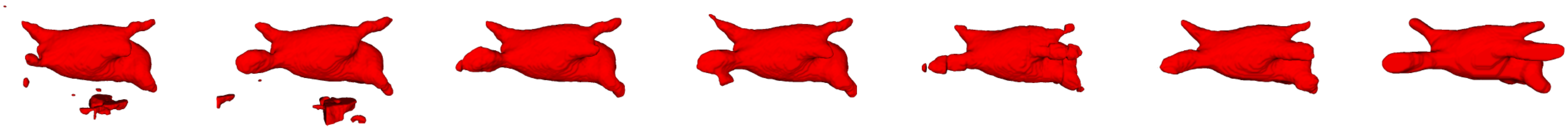


Experiments

Table 1. 5-fold cross-validation comparison results on the LA MRI dataset (average ± standard deviation)

Method	Volumes used		Metrics			
	Labeled	Unlabeled	Dice(%)↑	Jaccard(%)↑	95HD(voxel)↓	ASD(voxel)↓
VNet	80(100%)	0	91.28±0.008	84.07±0.012	5.00±0.757	1.61±0.291
3D-ResVNet	80(100%)	0	91.09±0.013	83.90±0.017	4.77±1.641	1.75±0.195
VNet	16(20%)	0	83.34±0.023	72.49±0.029	14.77±1.169	3.87±0.337
3D-ResVNet	16(20%)	0	84.09±0.022	73.56±0.025	17.36±2.748	4.96±1.008
MT	16(20%)	64	85.89±0.024	76.58±0.027	12.63±5.741	3.44±1.382
UA-MT	16(20%)	64	85.98±0.014	76.65±0.017	9.86±2.707	2.68±0.776
SASSNet	16(20%)	64	86.21±0.023	77.15±0.024	9.80±1.842	2.68±0.416
DTC	16(20%)	64	86.36±0.023	77.25±0.020	9.02±1.015	2.40±0.223
*MC-Net	16(20%)	64	87.65±0.011	78.63±0.013	9.70±2.361	3.01±0.700
MCF(Ours)	16(20%)	64	**88.71±0.018**	**80.41±0.022**	**6.32±0.800**	**1.90±0.187**

* means we report our reproduced results here because MC-Net does not release source code.



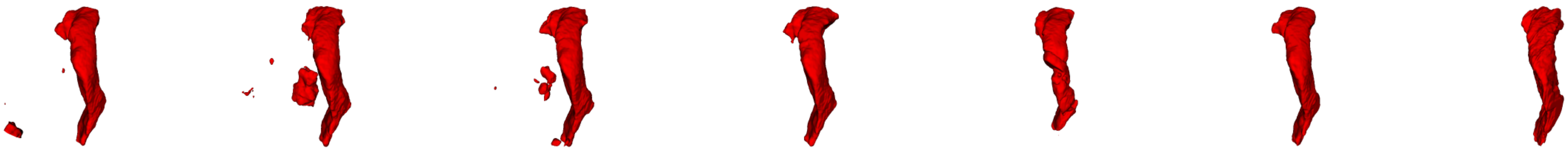
(a) MT (b) UA-MT (c) SASSNet (d) DTC (e) MCNet (f) Ours (g) GT

Experiments

Table 2. 4-fold cross-validation comparison results on the Pancreas CT dataset (average ± standard deviation)

Method	Volumes used		Metrics			
	Labeled	Unlabeled	Dice(%)↑	Jaccard(%)↑	95HD(voxel)↓	ASD(voxel)↓
VNet	62(100%)	0	80.75±0.010	68.49±0.014	7.23±0.564	1.69±0.363
3D-ResVNet	62(100%)	0	79.78±0.021	67.29±0.025	7.30±1.632	1.60±0.074
VNet	12(20%)	0	64.18±0.073	49.26±0.077	17.74±3.572	4.69±0.935
3D-ResVNet	12(20%)	0	66.53±0.043	51.25±0.047	19.01±4.129	5.64±1.467
MT	12(20%)	50	74.43±0.024	60.53±0.030	14.93±2.000	4.61±0.929
UA-MT	12(20%)	50	74.01±0.029	60.00±3.031	17.00±3.031	5.19±1.267
SASSNet	12(20%)	50	73.57±0.017	59.71±0.020	13.87±1.079	3.53±1.416
DTC	12(20%)	50	73.23±0.024	59.18±0.027	13.20±2.241	3.81±0.953
*MC-Net	12(20%)	50	73.73±0.019	59.19±0.021	13.65±3.902	3.92±1.055
MCF(Ours)	12(20%)	50	**75.00±0.026**	**61.27±0.030**	**11.59±1.611**	**3.27±0.919**

* means we report our reproduced results here because MC-Net does not release source code.



(a) MT (b) UA-MT (c) SASSNet (d) DTC (e) MCNet (f) Ours (g) GT

Experiments

Effects of different components.

Method	Metrics			
	Dice(%)↑	Jaccard(%)↑	95HD(voxel)↓	ASD(voxel)↓
V	85.63	75.67	14.40	3.69
V+CDR	87.69	78.34	8.57	2.31
V+DCPLG	89.81	81.62	7.32	2.36
R	85.67	75.49	13.16	3.25
R+CDR	87.57	78.14	9.03	2.34
R+DCPLG	89.27	80.69	6.86	2.10
V-m-R	86.53	76.89	11.30	2.70
V+R+CDR	88.21	79.16	7.89	1.98
V+R+DCPLG	90.13	81.92	6.73	1.86
MCF	90.49	82.70	5.62	1.61

"V" refers to VNet
"R" refers to 3D-ResVNet
V-m-R refers integrating VNet and 3D-ResNet with the averaging operation

Experiments

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Ablation for rectification loss

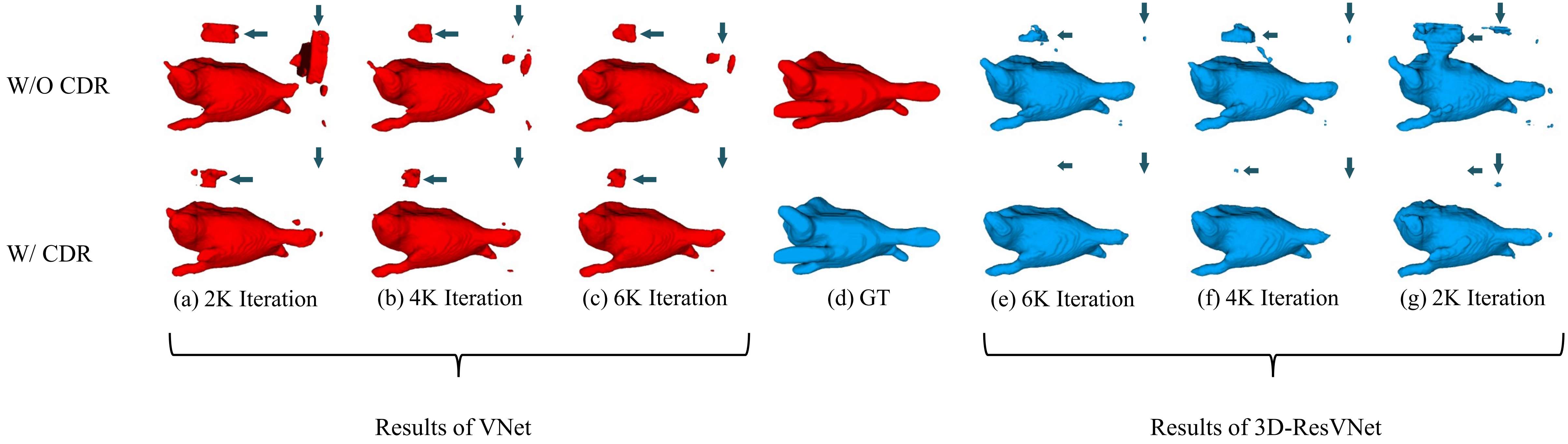
Loss function	Metrics			
	Dice(%)↑	Jaccard(%)↑	95HD(voxel)↓	ASD(voxel)↓
CE loss	90.28	82.34	5.60	1.68
MSE loss	90.49	82.70	5.62	1.61

Ablation for different values of β

β	Metrics			
	Dice(%)↑	Jaccard(%)↑	95HD(voxel)↓	ASD(voxel)↓
0.3	90.23	82.32	5.89	1.69
0.4	90.27	82.41	5.85	1.64
0.5	90.49	82.70	5.62	1.61
0.6	90.26	82.43	5.86	1.65
0.7	90.24	82.38	5.88	1.67

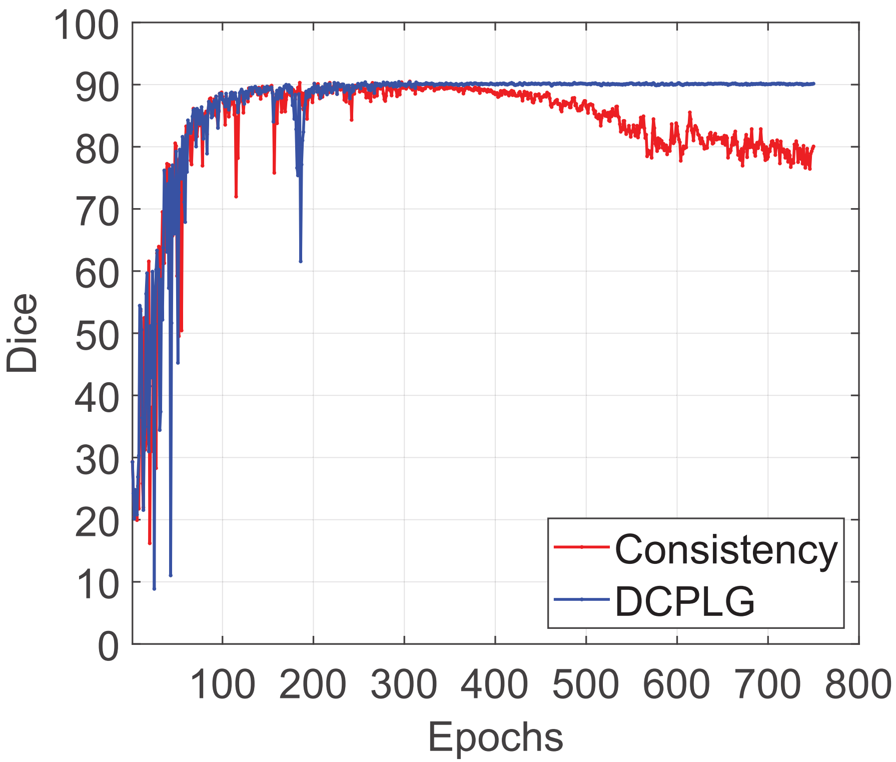
Experiments

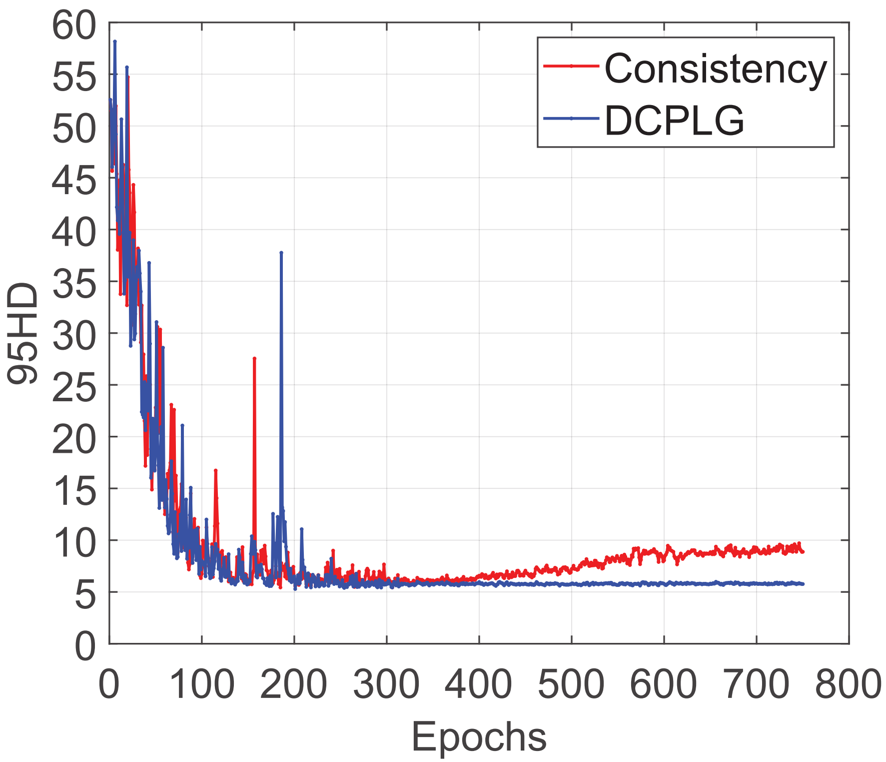
Effects of CDR



Experiments

consistency regularization VS training and DCPLG pseudo label training





Conclusion

- We propose a new framework called MCF for semi-supervised medical image segmentation, which enables the network to be aware of its own mistakes and perform bias correction through inter-subnet interactions.

- The CDR takes the difference predictions of the subnets as potential bias areas and guides the network to review and correct them.

- The DCPLG is used to dynamically select pseudo-label generators to improve the quality of pseudo-labels.