

Multi-modal segmentation with missing MR sequences

Using pre-trained fusion networks

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Paper:



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Introduction

BraTS Challenge

= Brain Tumor segmentation with **4 MR sequences**

Our goal:

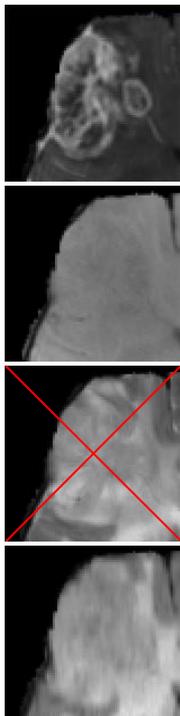
any combination of 4 sequences

Baseline: UNet

-> Input sequences as channels

	All	All but T1W	All but T1WC	All but T2W	All but FLAIR	T2W, FLAIR	T1WC, FLAIR	T1WC, T2W	T1W, FLAIR	T1W, T2W	T1W, T1WC	FLAIR	T2W	T1WC	T1W
UNet	83	65	78	74	43	65	43	46	63	23	18	37	30	14	4
Dedicated	83	81	81	79	73	79	77	74	76	72	59	73	71	49	48

Approach 1: Sequence dropout



Dropout of sequences during training

Increase p from 0 to 0.5 in steps

	All	All but T1W	All but T1WC	All but T2W	All but FLAIR	T2W, FLAIR	T1WC, FLAIR	T1WC, T2W	T1W, FLAIR	T1W, T2W	T1W, T1WC	FLAIR	T2W	T1WC	T1W
UNet	83	65	78	74	43	65	43	46	63	23	18	37	30	14	4
Dropout	77	76	81	76	59	73	62	59	77	61	33	51	60	21	8

Approach 2: Multipath

1. dropout

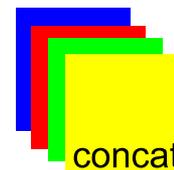
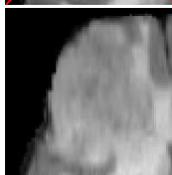
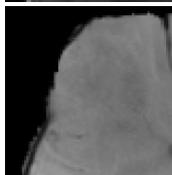
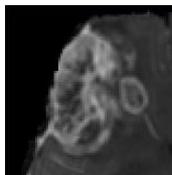
2. 3D U-Net

3. combine

4. classify

Each sequence its own UNet

Number of parameters constant



Approach 2: Multipath

Each sequence its own UNet

Number of parameters constant

	All	All but T1W	All but T1WC	All but T2W	All but FLAIR	T2W, FLAIR	T1WC, FLAIR	T1WC, T2W	T1W, FLAIR	T1W, T2W	T1W, T1WC	FLAIR	T2W	T1WC	T1W
	Whole tumor														
UNet	83	65	78	74	43	65	43	46	63	23	18	37	30	14	4
Dropout	77	76	81	76	59	73	62	59	77	61	33	51	60	21	8
Multipath	82	81	82	77	70	80	74	69	77	70	42	69	63	32	25

Approach 3: Shared representation

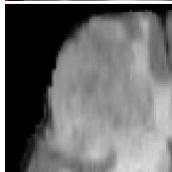
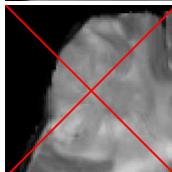
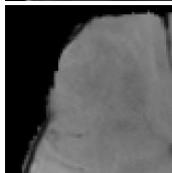
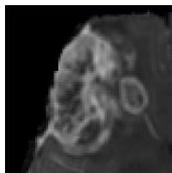
1. dropout

2. 3D U-Net

3. combine

4. classify

Idea: force similar feature representations across paths



mean

var



Approach 3: Shared representation

Idea: force similar feature representations across paths

	All	All but T1W	All but T1WC	All but T2W	All but FLAIR	T2W, FLAIR	T1WC, FLAIR	T1WC, T2W	T1W, FLAIR	T1W, T2W	T1W, T1WC	Whole tumor			
UNet	83	65	78	74	43	65	43	46	63	23	18	37	30	14	4
Dropout	77	76	81	76	59	73	62	59	77	61	33	51	60	21	8
Multipath	82	81	82	77	70	80	74	69	77	70	42	69	63	32	25
SharedRep	83	82	82	79	72	81	74	71	76	71	48	72	69	36	29
Dedicated	83	81	81	79	73	79	77	74	76	72	59	73	71	49	48

Approach 4: Pretraining

1. dropout

2. 3D U-Net

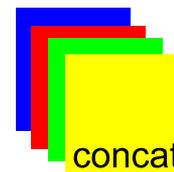
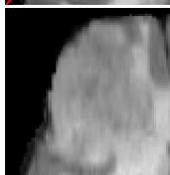
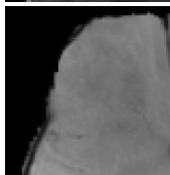
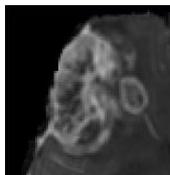
3. combine

4. classify

1. Train UNet paths separately

2. Train only last layer with sequence dropout

-> Longer training, but less memory!



or

mean

var



Approach 4: Pretraining

Idea: force similar feature representations across paths

	All	All but T1W	All but T1WC	All but T2W	All but FLAIR	T2W, FLAIR	T1WC, FLAIR	T1WC, T2W	T1W, FLAIR	T1W, T2W	T1W, T1WC	FLAIR	T2W	T1WC	T1W
	Whole tumor														
UNet	83	65	78	74	43	65	43	46	63	23	18	37	30	14	4
Dropout	77	76	81	76	59	73	62	59	77	61	33	51	60	21	8
Multipath	82	81	82	77	70	80	74	69	77	70	42	69	63	32	25
SharedRep	83	82	82	79	72	81	74	71	76	71	48	72	69	36	29
Multipath + Pretraining	84	83	83	82	75	82	78	74	78	73	56	72	70	49	44
SharedRep + Pretraining	83	83	82	81	74	81	77	72	79	73	58	75	69	52	44
Dedicated	83	81	81	79	73	79	77	74	76	72	59	73	71	49	48

Conclusions

Segmentation with missing sequences

-> No need to train dedicated networks!

Pretraining improves multipath network

Shared representations...

	All	All but T1W	All but T1WC	All but T2W	All but FLAIR	T2W, FLAIR	T1WC, FLAIR	T1WC, T2W	T1W, FLAIR	T1W, T2W	T1W, T1WC	FLAIR	T2W	T1WC	T1W
	Whole tumor														
UNet	83	65	78	74	43	65	43	46	63	23	18	37	30	14	4
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