Multi-modal segmentation with missing MR sequences
Using pre-trained fusion networks

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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
Approach 1: Sequence dropout

Dropout of sequences during training

Increase $p$ from 0 to 0.5 in steps
Approach 2: Multipath

Each sequence its own U-Net

Number of parameters constant
Approach 2: Multipath

Each sequence its own UNet

Number of parameters constant
Approach 3: Shared representation

Idea: force similar feature representations across paths
Approach 3: Shared representation

Idea: force similar feature representations across paths

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

Whole tumor
Approach 4: Pretraining

1. Train UNet paths separately

2. Train only last layer with sequence dropout

-> Longer training, but less memory!
### 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 | T1W, FLAIR | T1WC, FLAIR | T1W, T2W | T1W, T1WC | Whole tumor |
|----------------|-----|-------------|-------------|-------------|---------------|------------|------------|-------------|-----------|-----------|-------------|
| UNet           | 83  | 65          | 78          | 74          | 43            | 65         | 43         | 46          | 63        | 23        | 18          |
| Dropout        | 77  | 76          | 81          | 76          | 59            | 73         | 62         | 59          | 77        | 61        | 33          |
| Multipath      | 82  | 81          | 82          | 77          | 70            | 80         | 74         | 69          | 77        | 70        | 42          |
| SharedRep      | 83  | 82          | 82          | 79          | 72            | 81         | 74         | 71          | 76        | 71        | 48          |
| Multipath + Pretraining | 84  | 83          | 83          | 82          | 75            | 82         | 78         | 74          | 78        | 73        | 56          |
| SharedRep + Pretraining | 83  | 83          | 82          | 81          | 74            | 81         | 77         | 72          | 79        | 73        | 58          |
| Dedicated      | 82  | 81          | 81          | 79          | 73            | 79         | 77         | 74          | 76        | 72        | 59          |

Erasmus MC
Conclusions

Segmentation with missing sequences
- No need to train dedicated networks!

Pretraining improves multipath network

Shared representations...
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