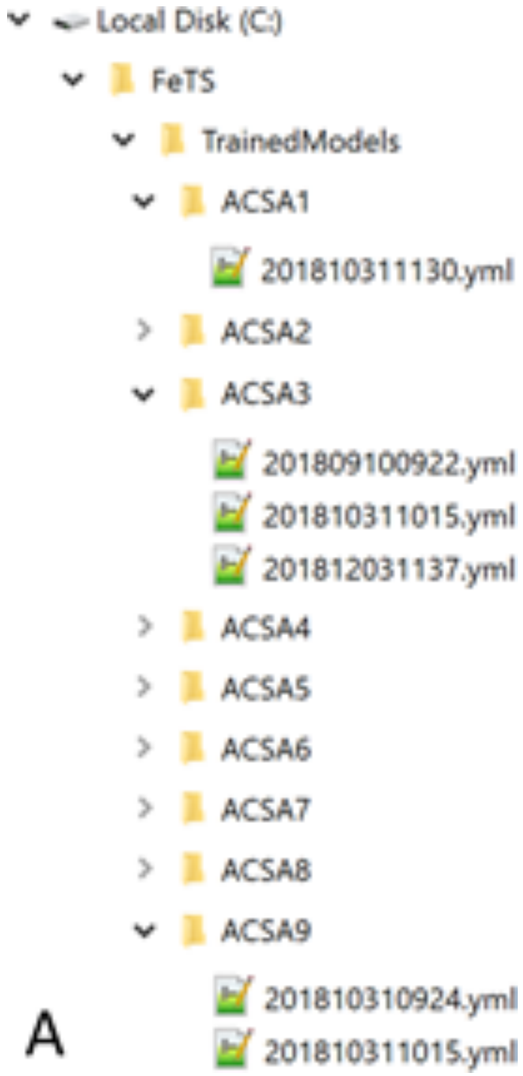
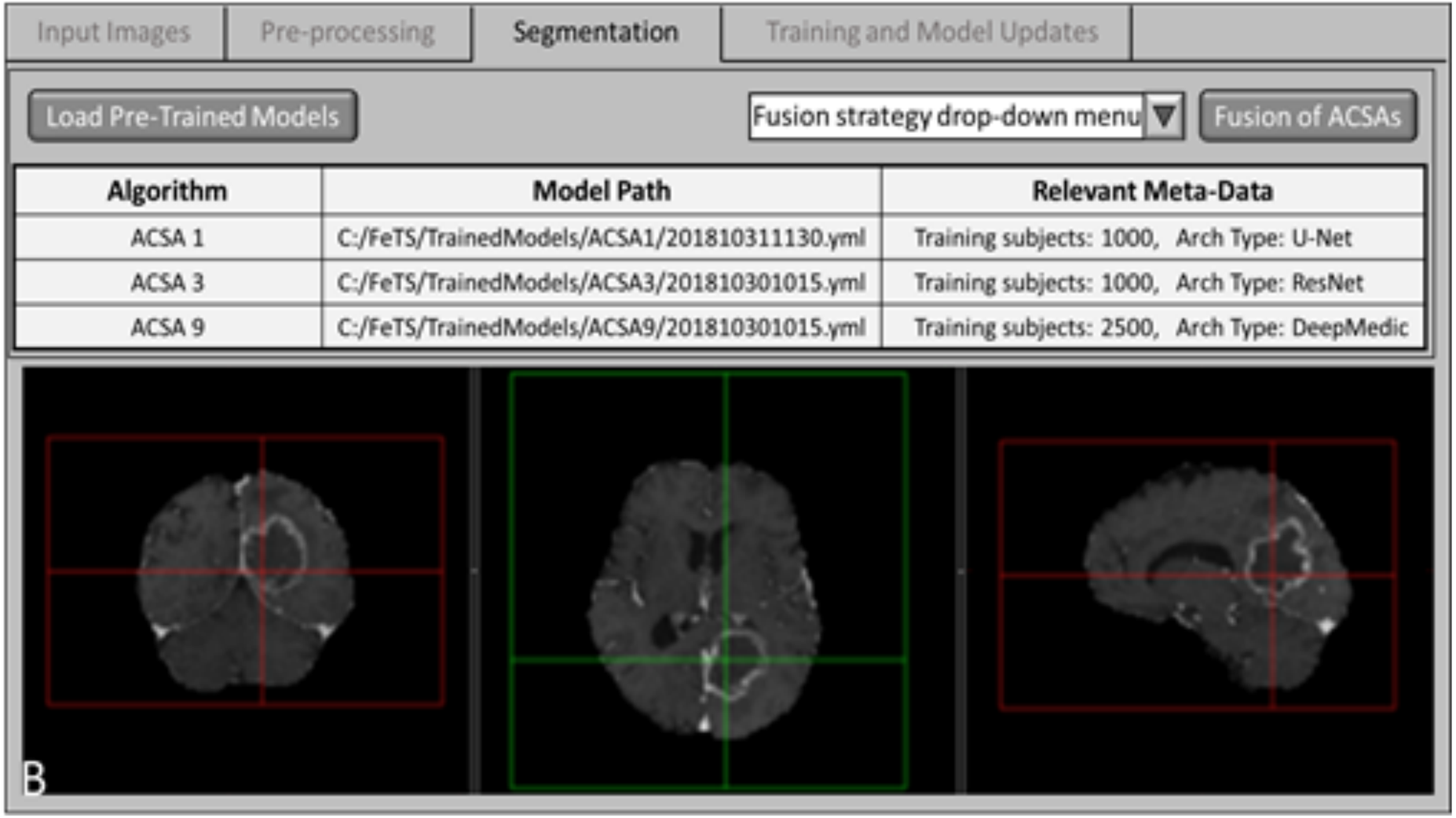
FeTS Segmentation & Label Fusion

Federated Tumor Segmentation

FeTS Segmentation & Label Fusion Wireframe

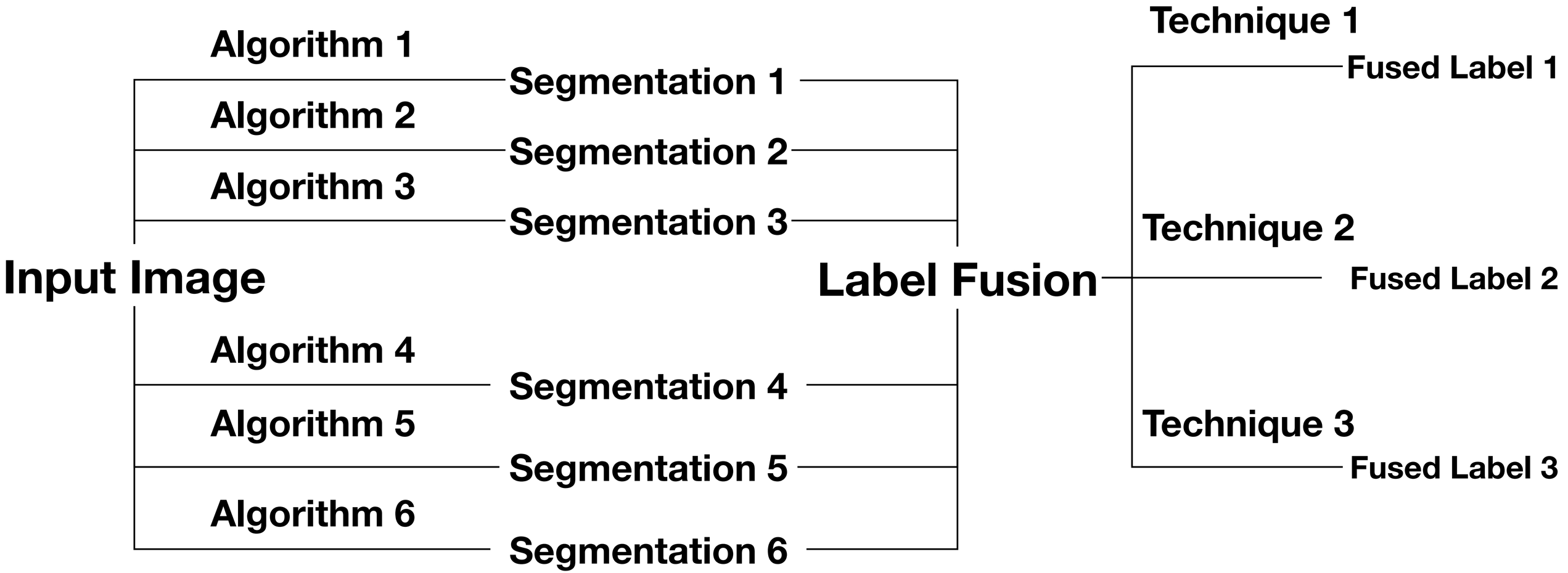


A



B

Basic FeTS Concept



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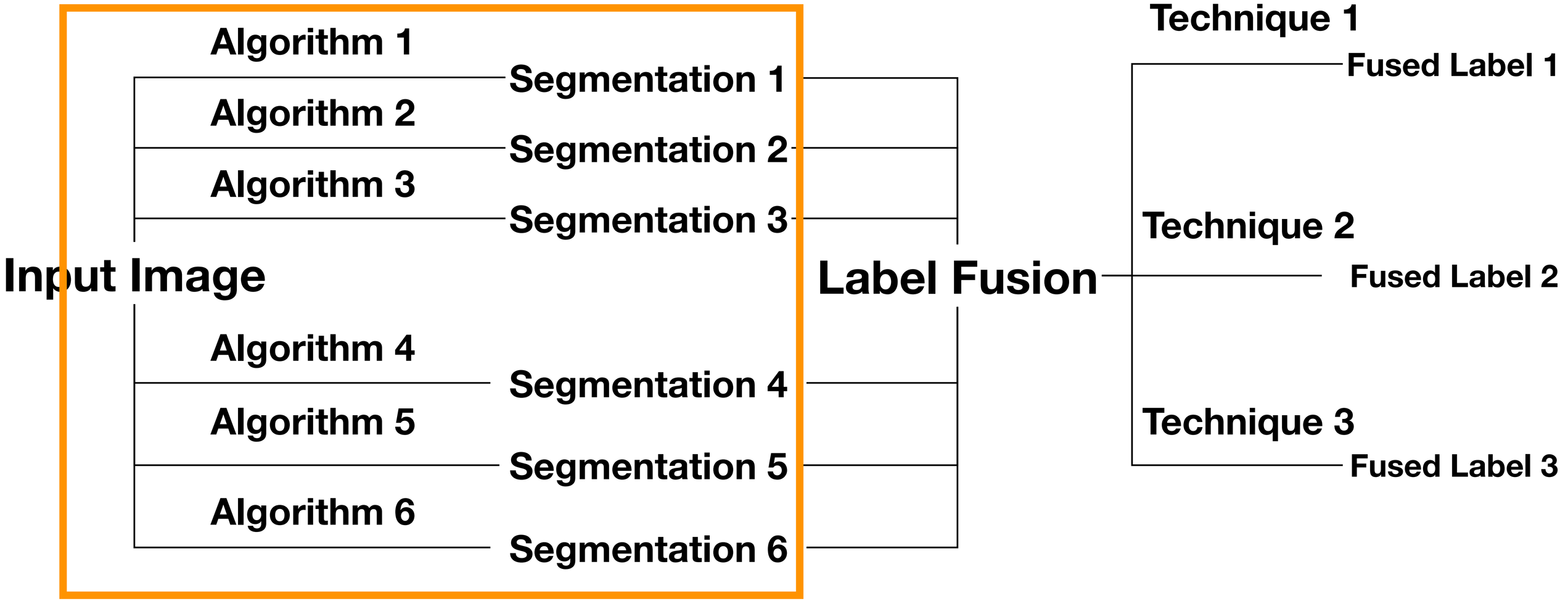

Segmentation algorithms :
1. In-house
2. BraTS Algorithmic Respository

In-house Segmentation Algorithms

In-house Segmentation Algorithms

- 3D U-Net
- 3D Residual U-Net
- FCN
- Deep Medic (Pre-trained weights from the cluster)

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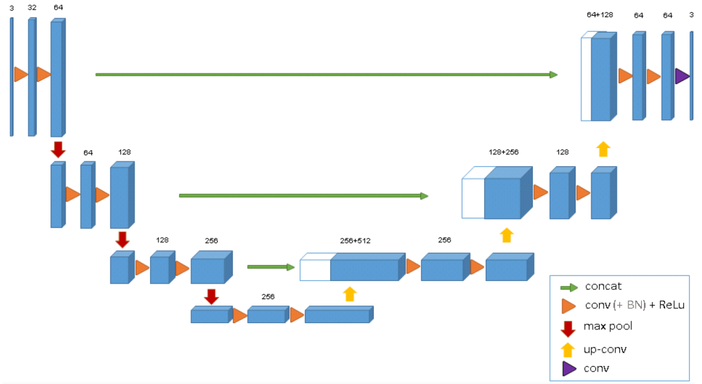
Variations of the similar kind of U-Net Architecture



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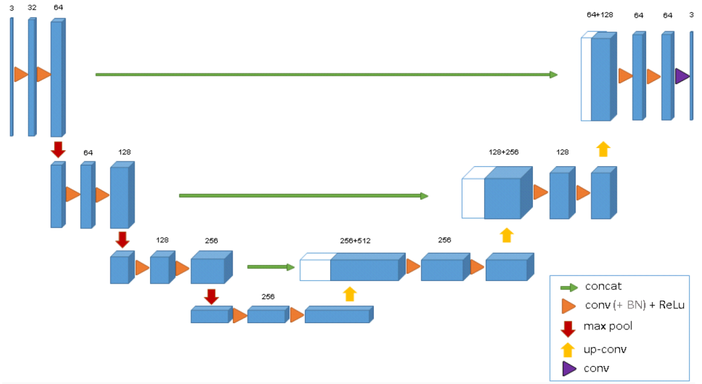

- Deep Medic (Pre-trained weights from the cluster)
- Inception (Still in experimental phase)

BraTS Segmentation Algorithms

BraTS Segmentation Algorithms

- Algorithms from BraTS-2018 challenge (Names given below are the team names):
  - MIC-DKFZ (TU Munich)
  - PVG-18 (McGill University)
  - GBMNET-18 (University of Washington)

Where were the BraTS-18 Algorithms obtained from?

https://hub.docker.com

12 Algorithms in different frameworks ……

6 algorithms in

5 Algorithms working inside their respective dockers

1 didn’t work due to a bug in the inference script

```
Traceback (most recent call last):
  File "DeepSCAN_BRATS.py", line 914, in <module>
    mask,5, axis=0)
  File "DeepSCAN_BRATS.py", line 537, in apply_to_case
    outputs, logit_flip = model(images[0])
  File "/cbica/home/bhaleram/.conda/envs/mckinley-scan18/lib/python3.6/site-packages/torch/nn/modules/module.py", line 489, in __call__
    result = self.forward(*input, **kwargs)
  File "DeepSCAN_BRATS.py", line 301, in forward
    out = self.depth_reducing_layers[i](out)
  File "/cbica/home/bhaleram/.conda/envs/mckinley-scan18/lib/python3.6/site-packages/torch/nn/modules/module.py", line 489, in __call__
    result = self.forward(*input, **kwargs)
  File "/cbica/home/bhaleram/.conda/envs/mckinley-scan18/lib/python3.6/site-packages/torch/nn/modules/container.py", line 92, in forward
    input = module(input)
  File "/cbica/home/bhaleram/.conda/envs/mckinley-scan18/lib/python3.6/site-packages/torch/nn/modules/module.py", line 489, in __call__
    result = self.forward(*input, **kwargs)
  File "/cbica/home/bhaleram/.conda/envs/mckinley-scan18/lib/python3.6/site-packages/torch/nn/modules/padding.py", line 276, in forward
    return F.pad(input, self.padding, 'replicate')
  File "/cbica/home/bhaleram/.conda/envs/mckinley-scan18/lib/python3.6/site-packages/torch/nn/functional.py", line 2683, in pad
    assert len(pad) == 4, '4D tensors expect 4 values for padding'
AssertionError: 4D tensors expect 4 values for padding
```

3 working algorithms (outside the docker) - one didn't work due to a permission issue and the other due to an environment issue

Thus, we end up with…..

- MIC-DKFZ (TU Munich)
- PVG-18 (McGill University)
- GBMNET-18 (University of Washington)

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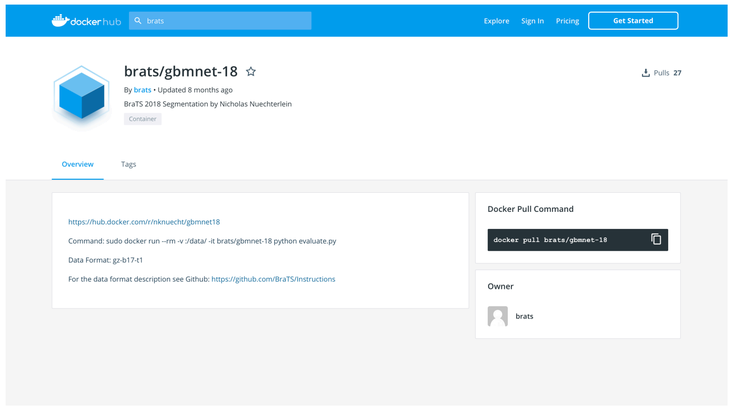

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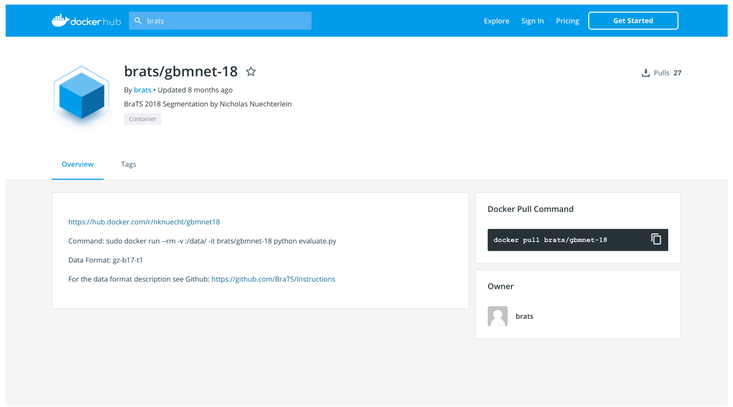

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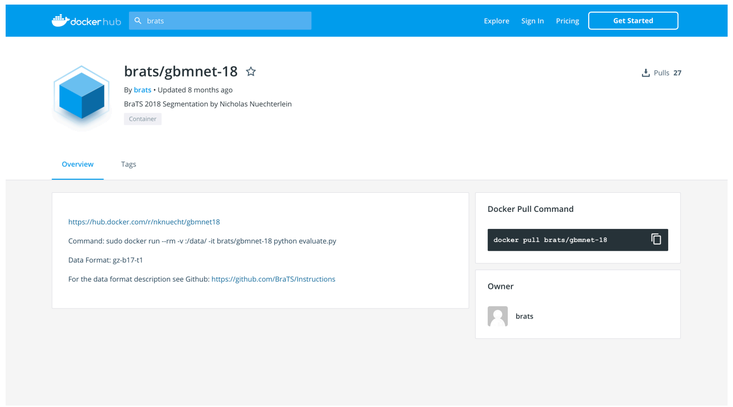

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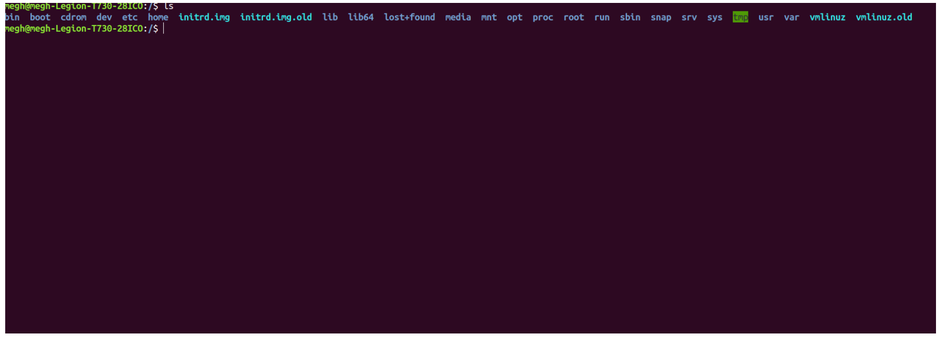

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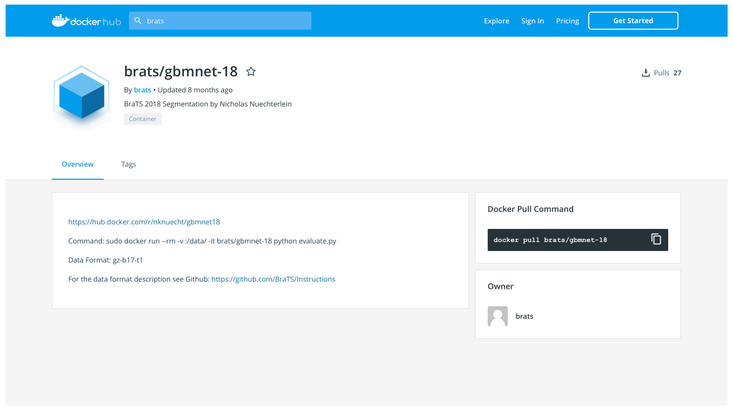

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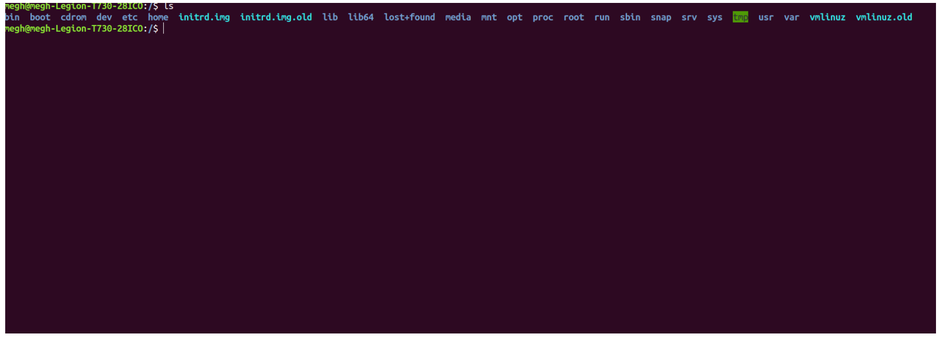

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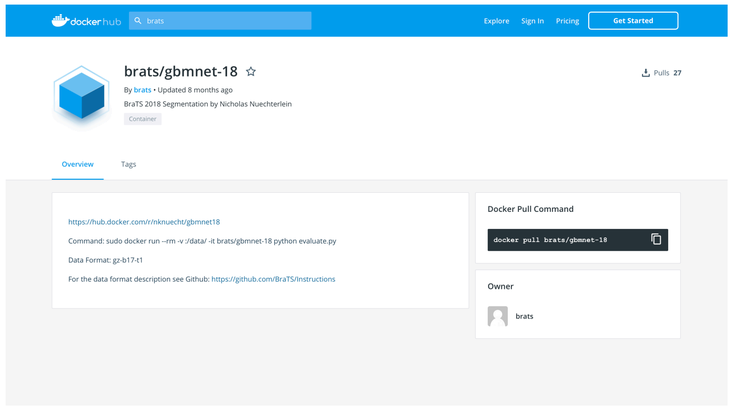

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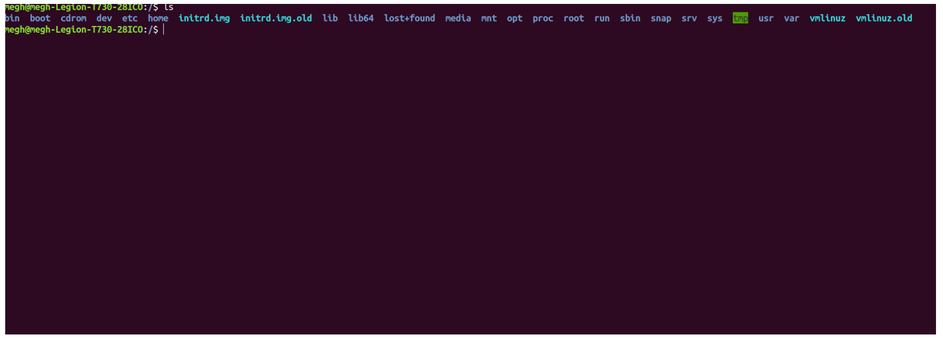

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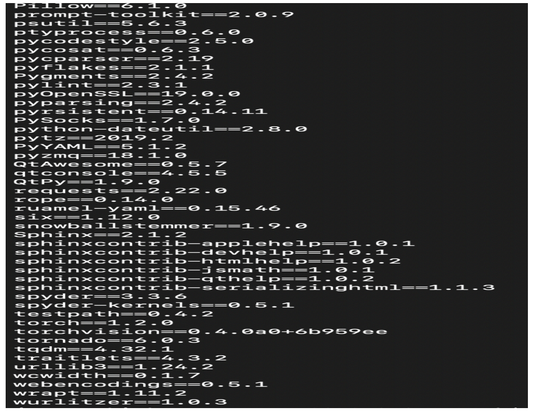

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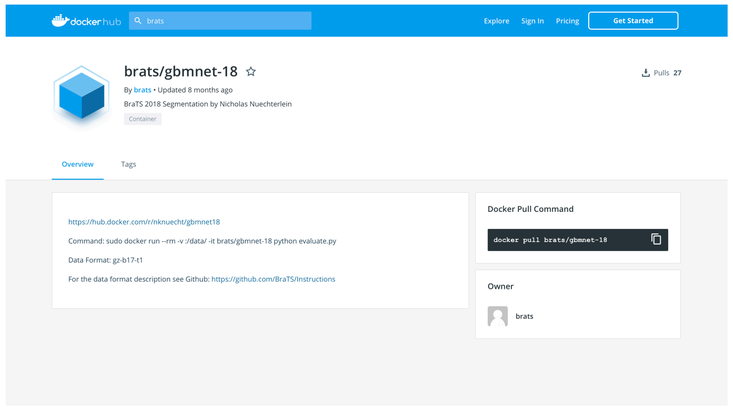

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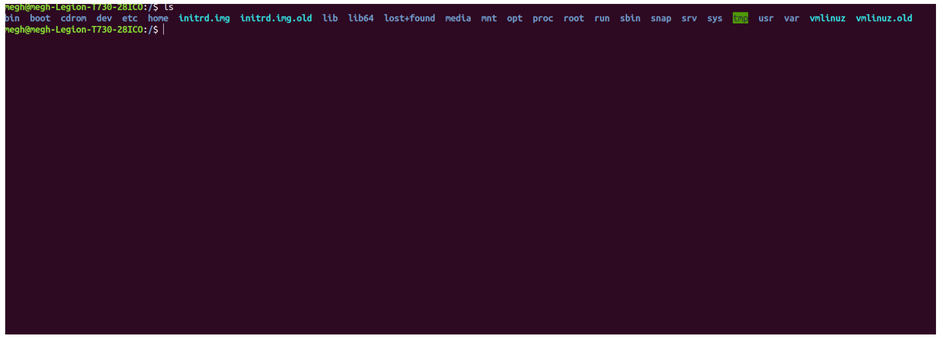

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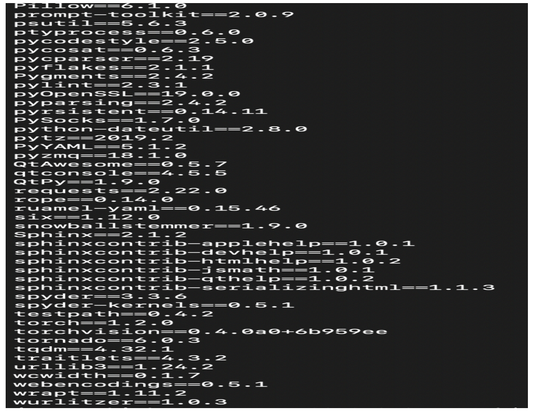

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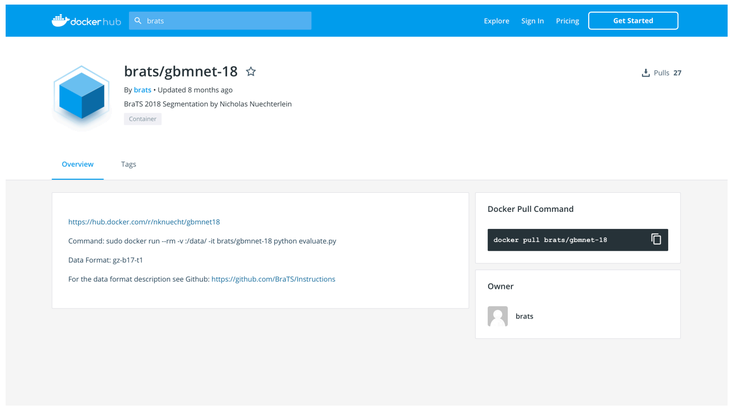

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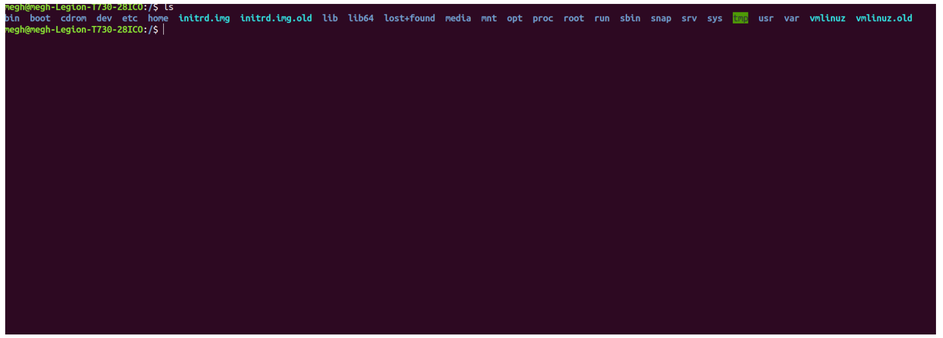

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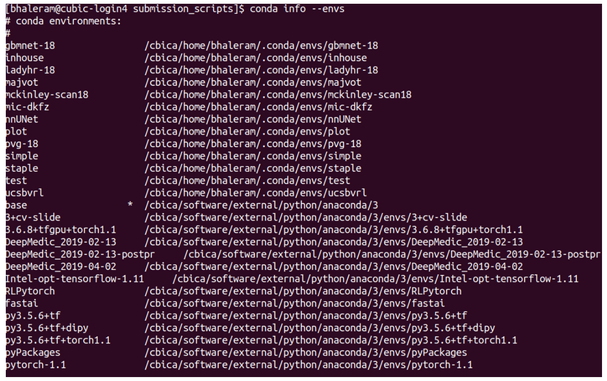
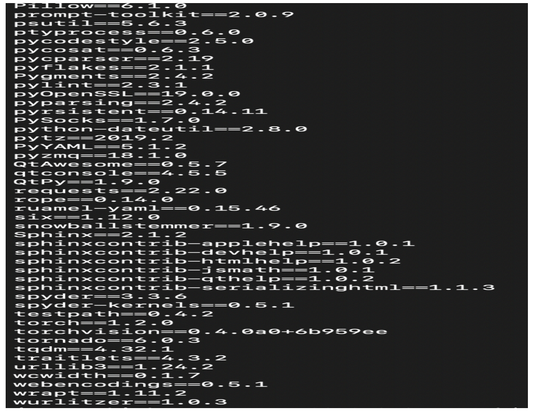


Create a virtual environment for each algorithm (including in-house) and install all the necessary dependencies

Copy relevant items from “inside” the docker to local machine/cluster using the : docker cp …. command



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Activate virtual environment for each of the algorithms → **Run and debug each algorithm** → **Design inference script so as to accept image and model as command line arguments and output the segmentation**

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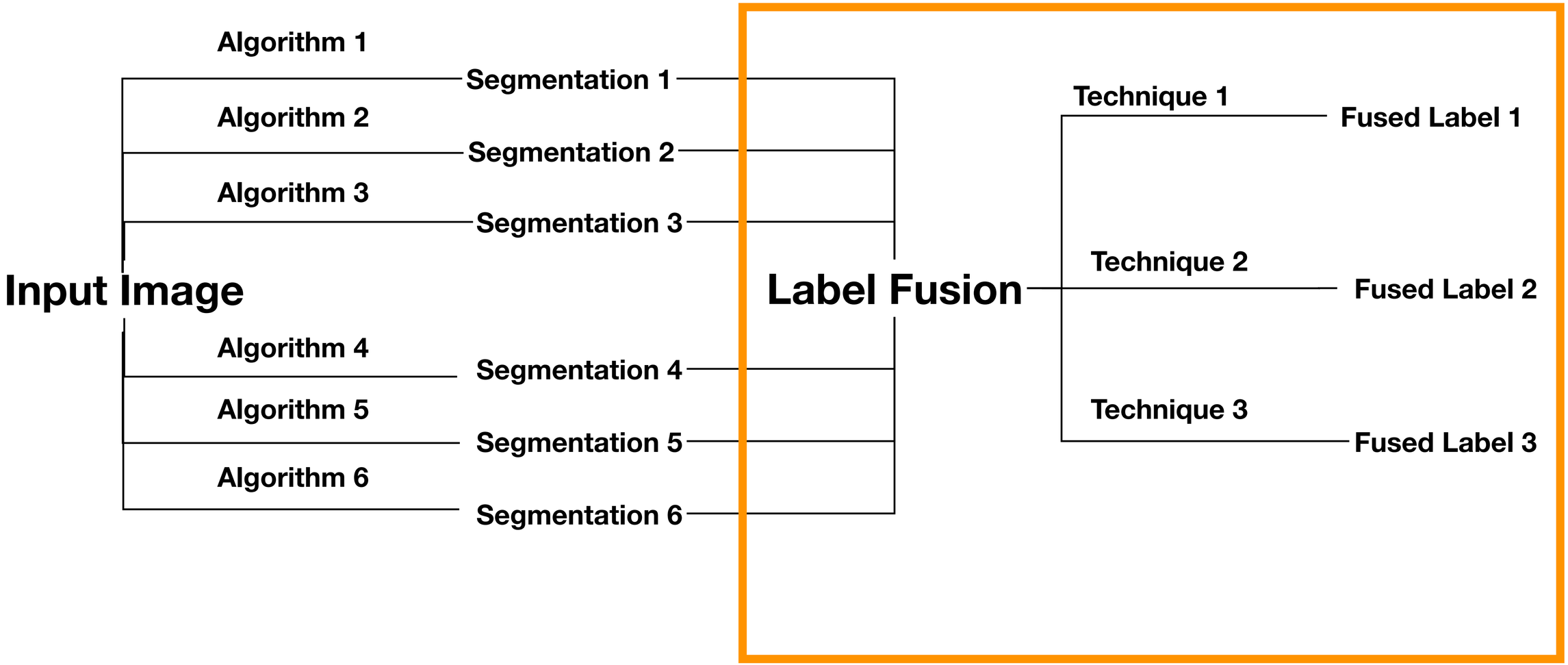

Label Fusion Approaches on the generated segmentations

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- **STAPLE** : Simultaneous Truth and Performance Level Estimation (Warfield SK, Zou KH, Wells WM. Simultaneous truth and performance level estimation (STAPLE): an algorithm for the validation of image segmentation. *IEEE Trans Med Imaging*. 2004;23(7): 903–921. doi:10.1109/TMI.2004.828354)

SIMPLE Label Fusion steps

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- Initial segmentation generated using voxel-wise majority voting

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- New consensus segmentation estimated using weighted majority voting with prior performance as weights.
- Worst performing segmentation is discarded and the two above steps are repeated till getting a final consensus segmentation

STAPLE Label Fusion steps

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- Expectation-Maximization Algorithm

https://pypi.org/project/staple/

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- Initial Assumption of Sensitivity (p) and Specificity (q) for each segmentation

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- Expectation-Maximization Algorithm
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- Maximization Step (M): Calculation of p and q based on this consensus segmentation

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STAPLE Label Fusion steps

- Expectation-Maximization Algorithm
- Initial Assumption of Sensitivity (p) and Specificity (q) for each segmentation
- Expectation Step (E): Calculation of consensus segmentation based on p,q and segmentations
- Maximization Step (M): Calculation of p and q based on this consensus segmentation
- Repeat Steps E and M till convergence (convergence calculated based on absolute diff b/w 2 subsequent predictions)

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Some Qualitative Results……

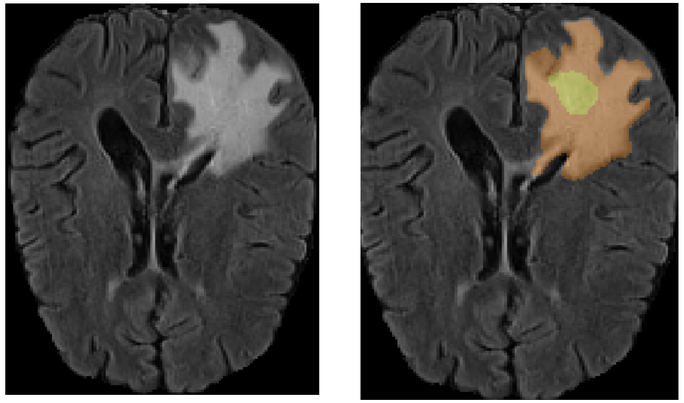
Inputs

Flair

T1ce

Inputs DeepMedic

Flair



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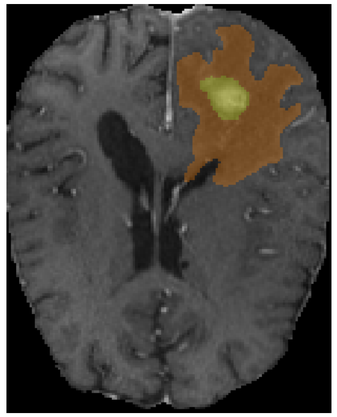

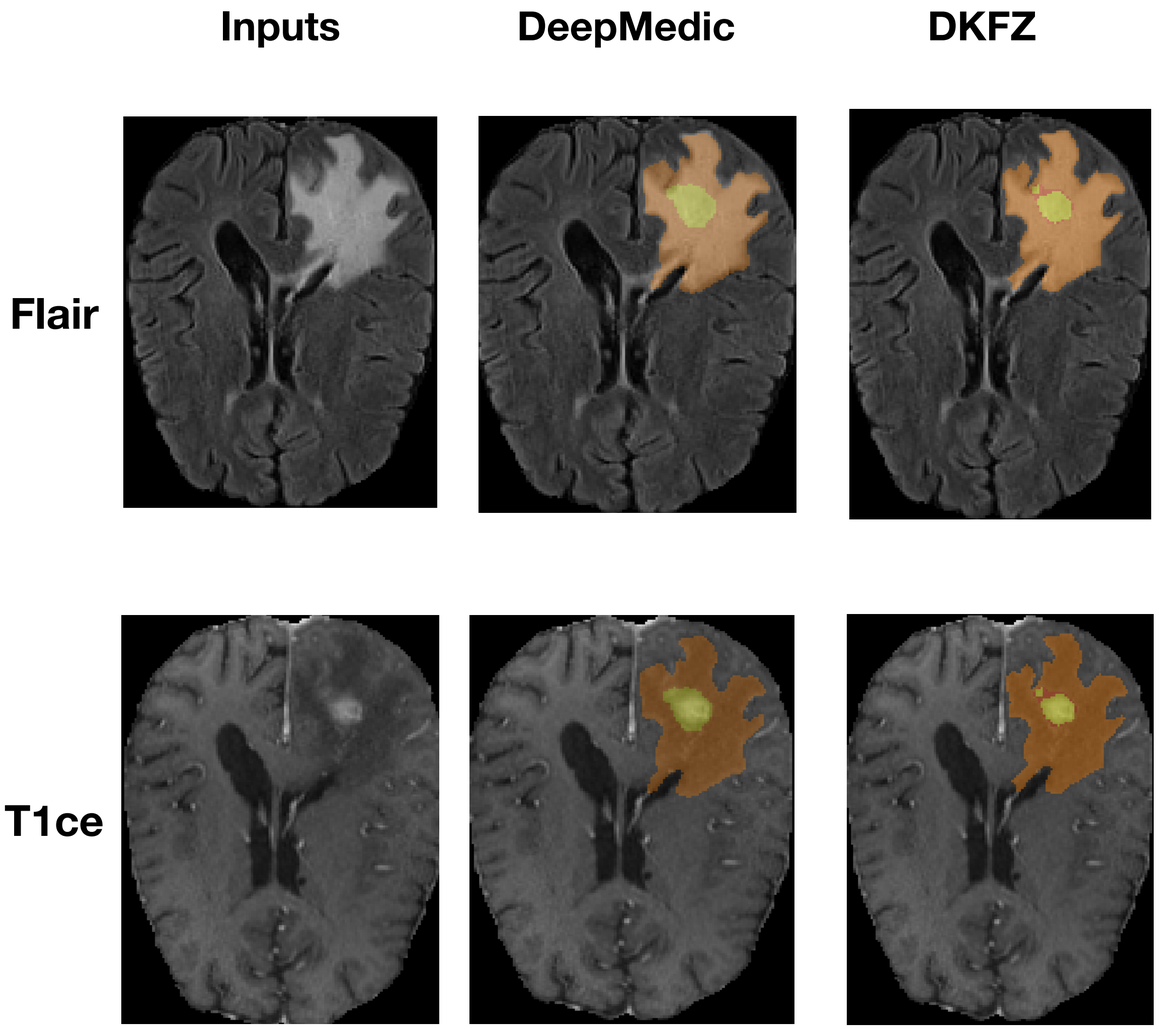
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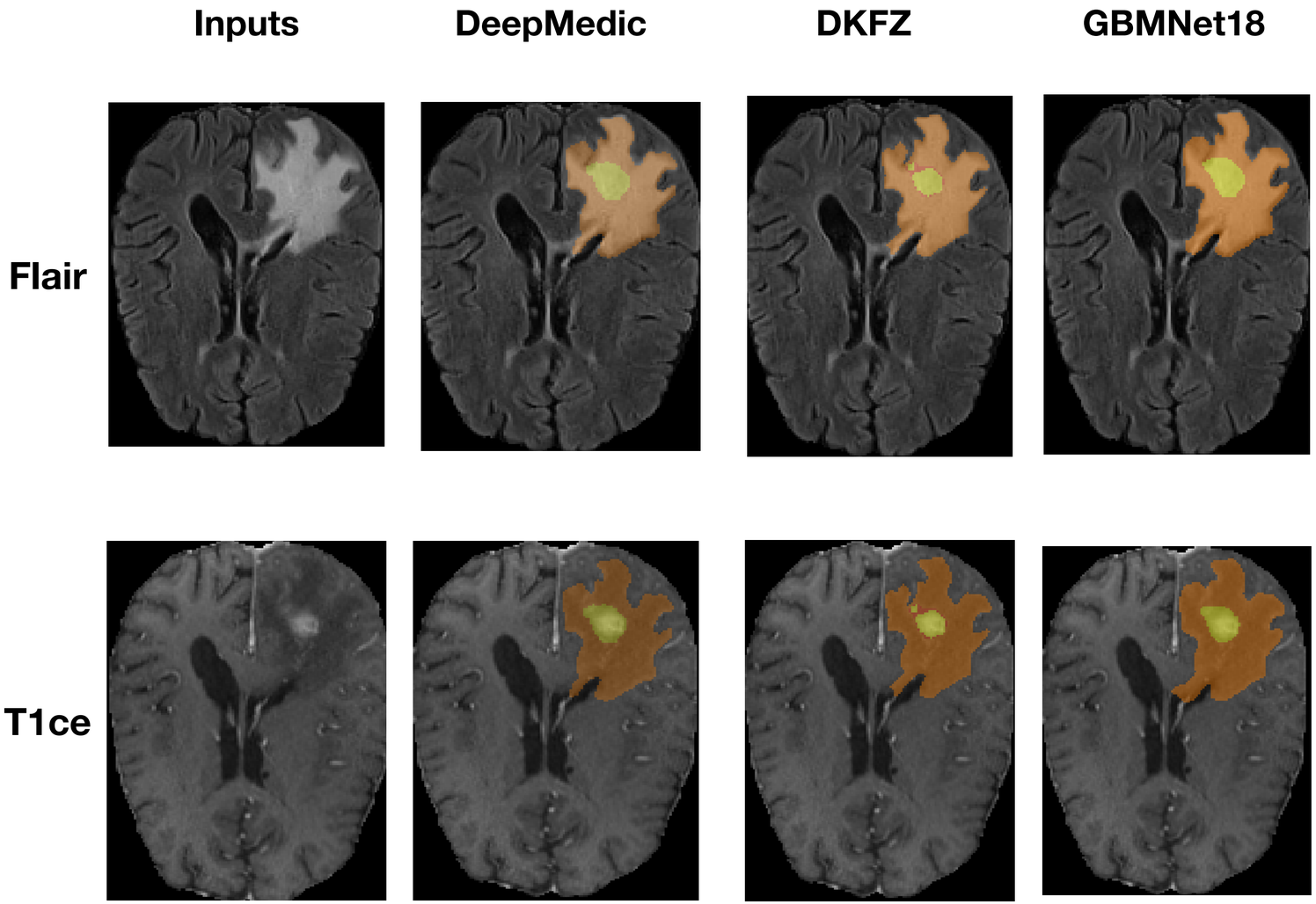
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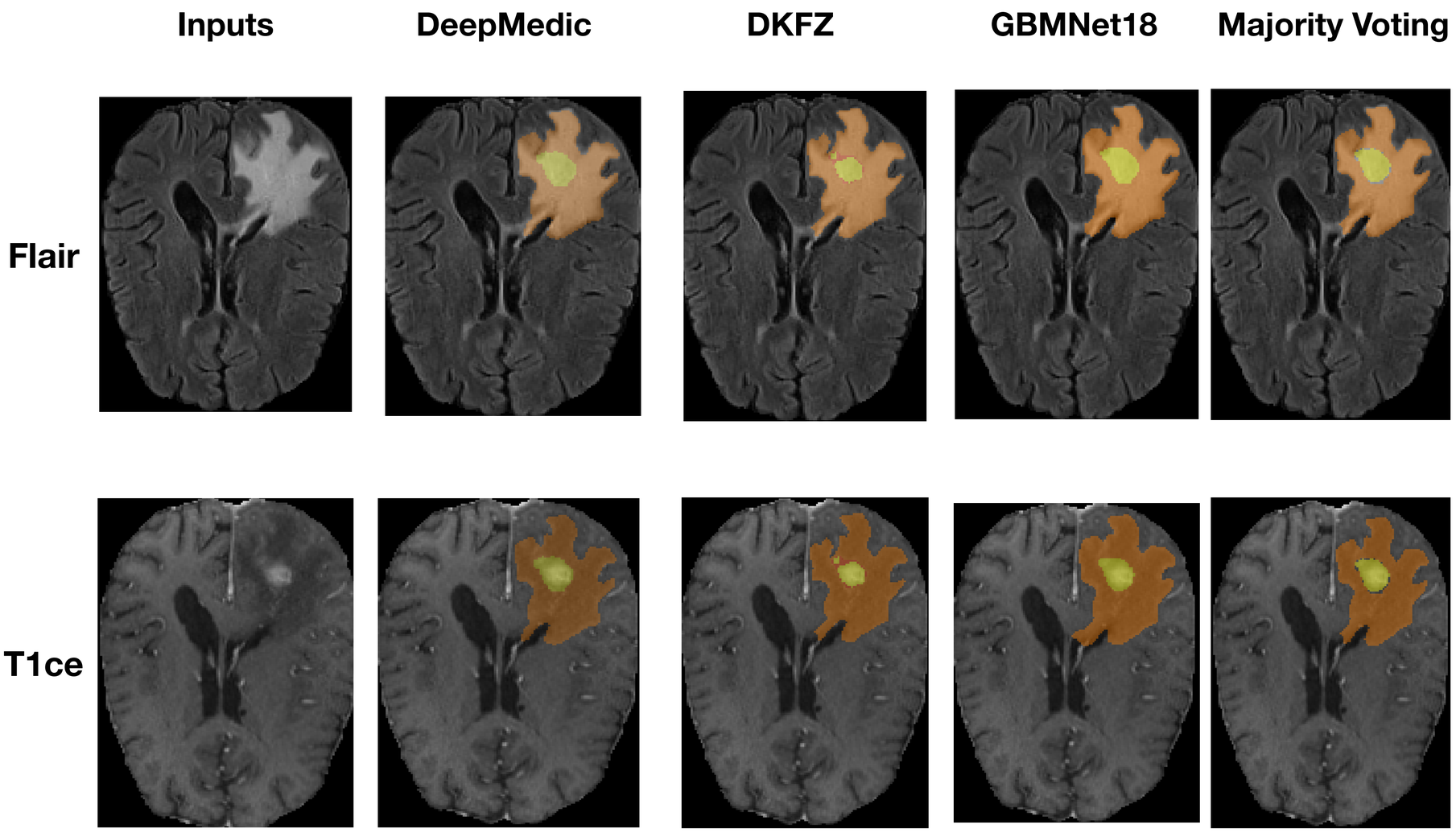
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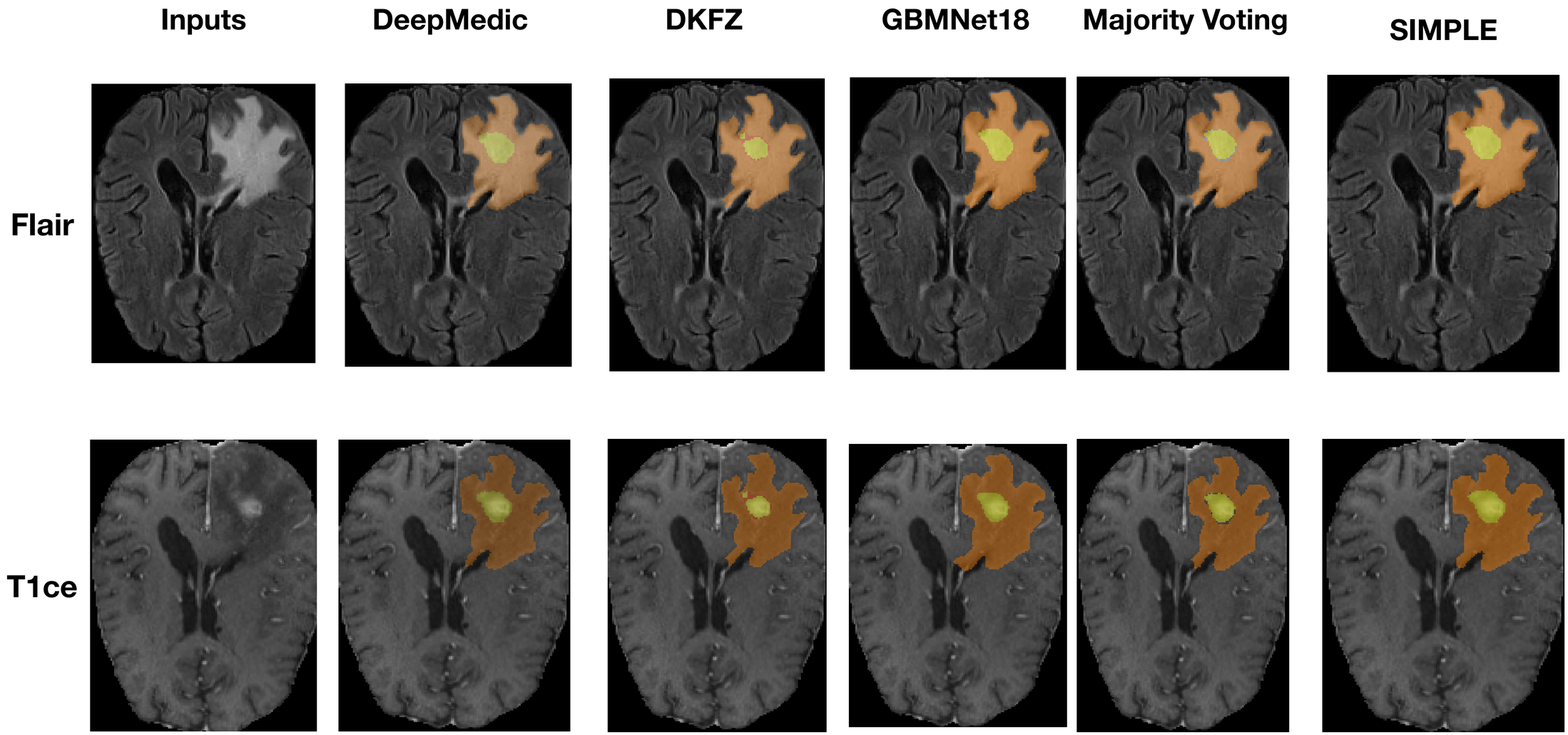
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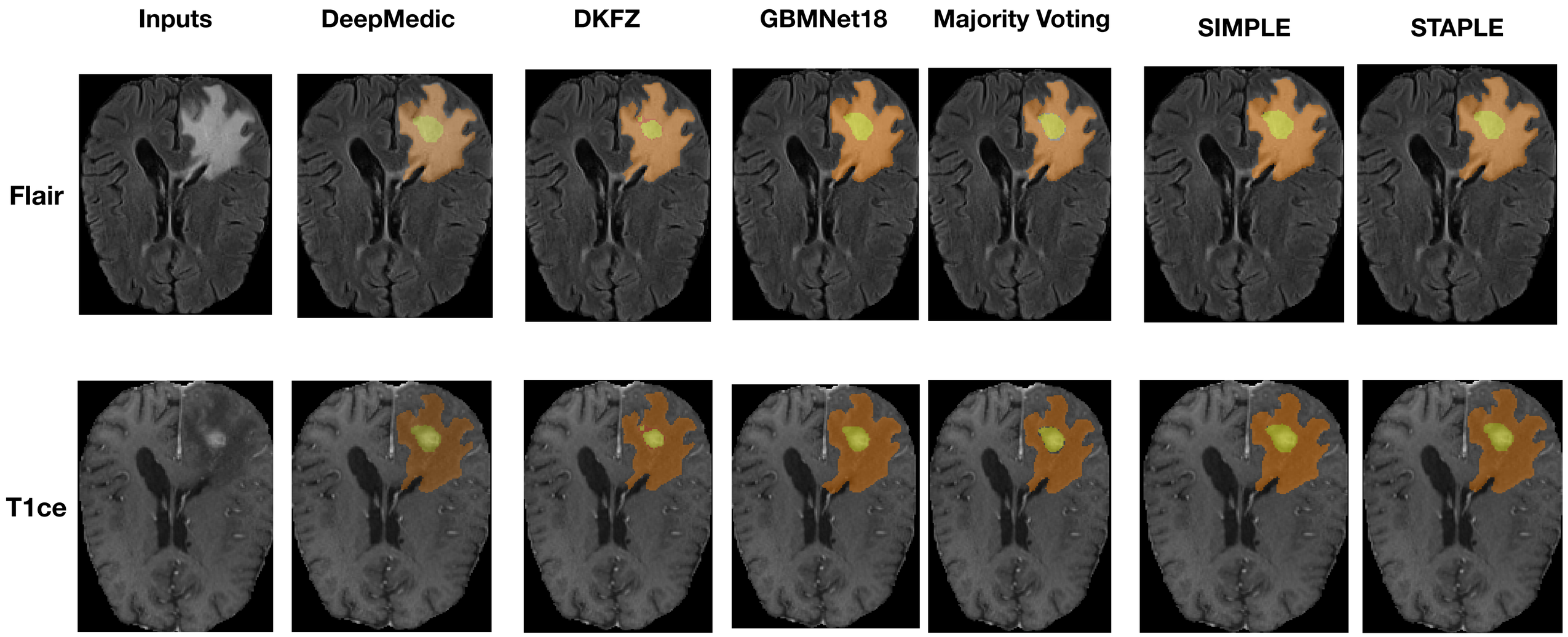
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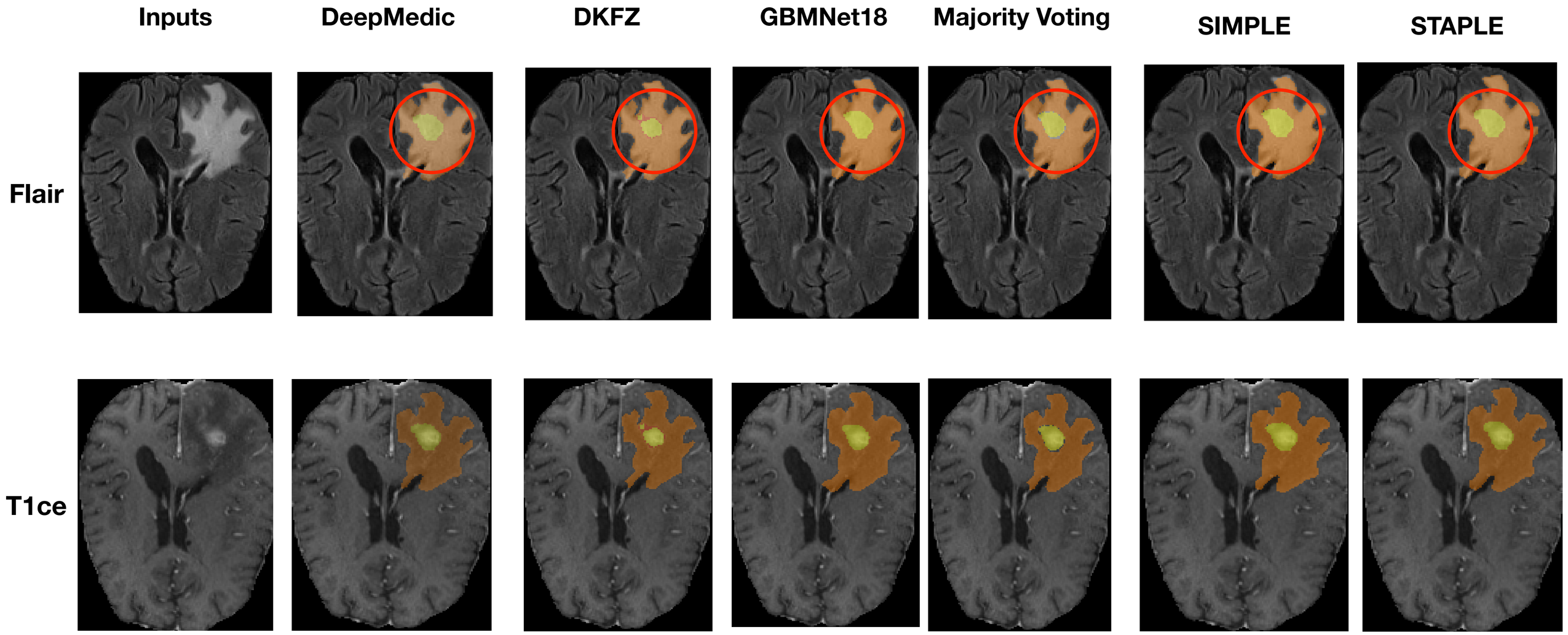
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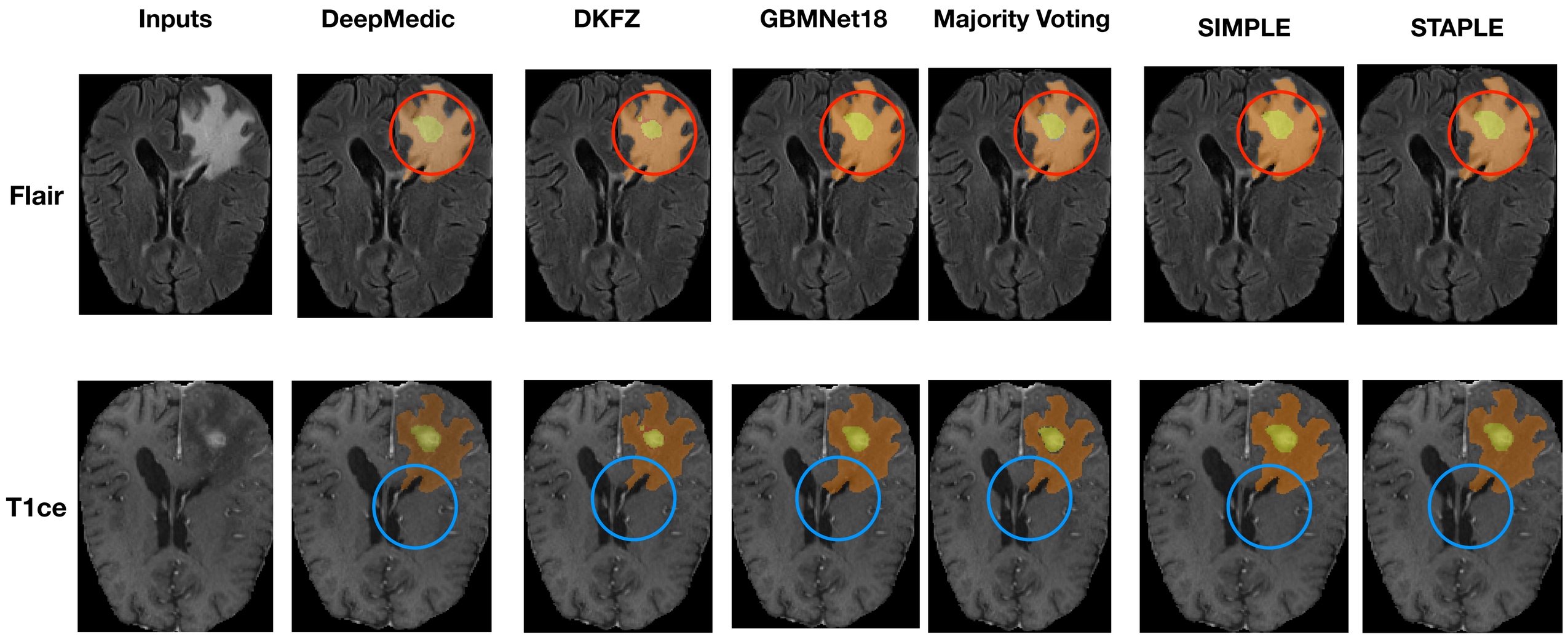
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