

## Research Problem

- **Uncertainty Quantification in segmentation:** In medical image segmentation, the annotations given by different experts won't be precisely the same. We need to quantify this kind of uncertainty.

## Basic Insights

- Compared to methods using a sizeable multi-stage network[1], training a subnet for each expert seems the best and most straightforward.
- Small data sets are well handled by ensembles and data augmentation, which decrease the impact of high variance.
- Despite a comparatively strong performance, the massive ensembles could cause a slower training and inference.

## Main Ideas

- Use ensembles of raters and train each rater with the corresponding experts, to learn characteristics individually.
- Again, use ensembles of U-Nets[2] to reduce the high variance.

## Methodology

- Each rater is trained only by the labels from its expert correspondingly (i.e., training in parallel).
- Each rater has an ensemble of 6 U-Nets, trained by 6-fold cross-validation that increases the model diversity.
- Data augmentation: random crop when training & sliding window inference.

## Methodology

### Bilayer Ensemble:

1. Ensembles of raters: each rater is trained by the corresponding expert.
2. Ensembles of U-Nets: 6 U-Nets for each rater.

: a single U-Net

: take average

: threshold with 0.5

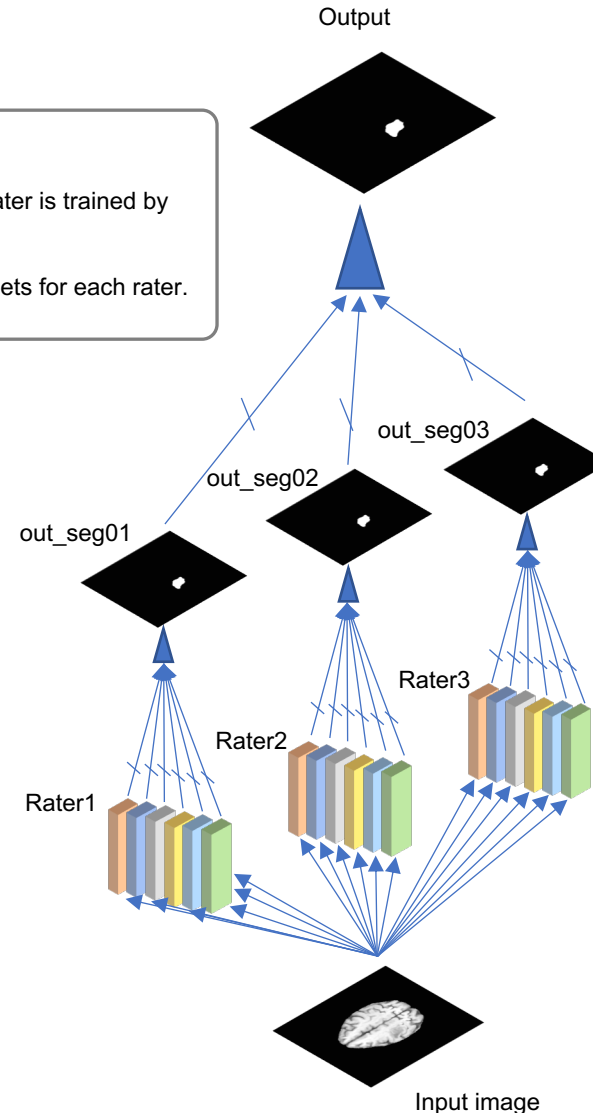
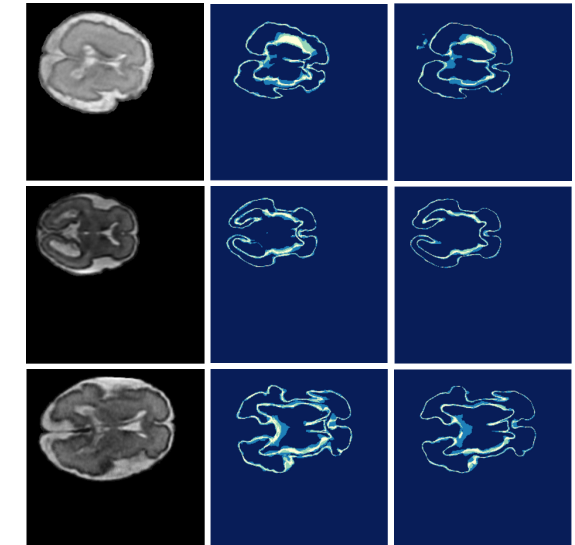


Fig1. Inference stage of our method.

## Visualization

- Uncertainty map examples in the validation set, brain growth.



(1) Image (2) GT (3) Our output

Fig2. Output Visualiazation (uncertainty map)

## References

1. Ji, W., Yu, S., Wu, J., Ma, K., Bian, C., Bi, Q., Li, J., Liu, H., Cheng, L., Zheng, Y.: Learning calibrated medical image segmentation via multi-rater agreement modeling. In: Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR). pp. 12341–12351 (June 2021)
2. Ronneberger, O., Fischer, P., Brox, T.: U-net: Convolutional networks for biomedical image segmentation (2015)
3. QUBIQ Challenge 2021, <https://qubiq21.grand-challenge.org/>. Last accessed 19 Sep 2021