Automatic Fetal Brain Segmentation for Prenatal MRI Screening

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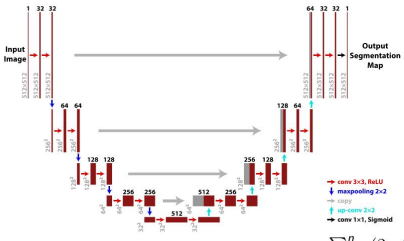
Background

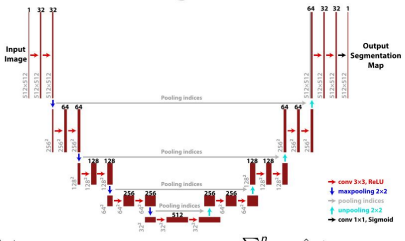
- Fetal imaging is the cornerstone of prenatal screening and diagnosis of congenital diseases.
- Despite the robust utility of MRI, interpreting fetal brain images represents a major challenge to radiologists and clinicians due to the rapidly changing architecture of the brain.
- Brain segmentation is the first step to identify abnormalities.

Model

UNet



SegNet



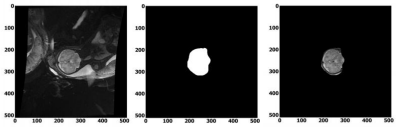
- Losses: BCE / $\mathcal{L}_{DICE}(y,\hat{y}) = 1 - \frac{\sum_{i=0}^{n}(2y_i\hat{y}_i) + \epsilon_0}{\sum_{i=0}^{n}(y_i + \hat{y}_i) + \epsilon_0}$ / $\mathcal{L}_{IOU}(y,\hat{y}) = 1 - \frac{\sum_{i=0}^{n} y_i\hat{y}_i + \epsilon_0}{\sum_{i=0}^{n}(y_i + \hat{y}_i - y_i\hat{y}_i) + \epsilon_0}$

Discussion

- Variance problem persists despite regularization, model architecture change, loss function choice and early stopping.
- This may indicate that we are possibly limited by the amount of training data.
- Further observation shows that the "ground truth" is not accurate enough.

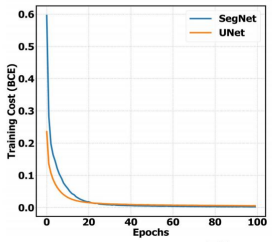
Dataset

- Data was provided by Prof. Kristen Yeom from the Stanford School of Medicine
- 690 fetal MRI scans in dicom format with masks in nifti format
- Each MRI scan contains ~ 15-35 slices in 512 × 512 resolution
- Approximately 10,000 images
- Division: 80%/10%/10% training/ dev/test sets

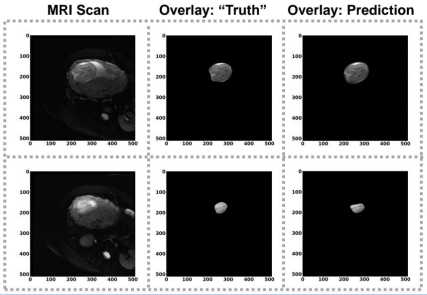


MRI Scan | Mask | Overlay image

Results



Metric: $IOU = \frac{TP}{TP + FP + FN}$



Model	Loss	Dropout	IoU (Training Set)	IoU (Dev Set)
Small UNet	BCE	0.5	0.91	0.77
Medium UNet	BCE	0.5	0.94	0.78
Medium UNet	IoU	0.5	0.90	0.71
Large UNet	BCE	0.5	0.91	0.74
SegNet	BCE	N/A	0.96	0.73

* Results are for 100 Epochs, with learning rate tuned for optimal performance on training set. Further study on early stopping does not show significant improvement.

Future Work

- Apply data augmentation
- Obtain more accurate "ground truth" for training
- Apply other regularization techniques to reduce variance problem
- Implement other semantic segmentation algorithms such as DeepLab

References

[1] O. Ronneberger *et al.*, *International Conference on Medical Image Computing and Computer Assisted-Intervention*, pp. 234-241,Springer, 2015

[2] V. Badrinarayanan *et al.*, *IEEE Transactions on Pattern Analysis & Machine Intellinge*, no. 12, pp. 2481-2495

[3] L. Chen *et al.*, *IEEE Transactions on Problem Analysis & Machine Intelligence*, Vol. 4, No. 4, pp. 834-848