Mitochondria Electron Microscope Image Segmentation

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BMENE4000 Deep Learning in Biomedical Engineering

Introduction

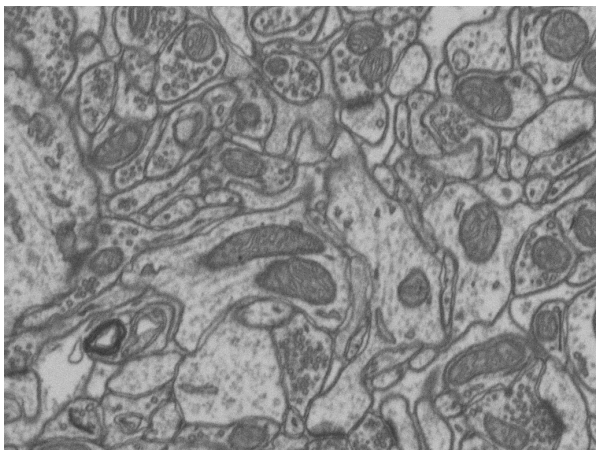
- The mitochondria play an important role in neural function. Recent studies show that mitochondrial morphology is crucial to cellular physiology and synaptic function and it is highly possible that a link between mitochondrial defects and neuro-degenerative diseases exists.
- **Data** EM Image of cerebral cortex section with mask labels (165 for training and 165 for test).

Outline

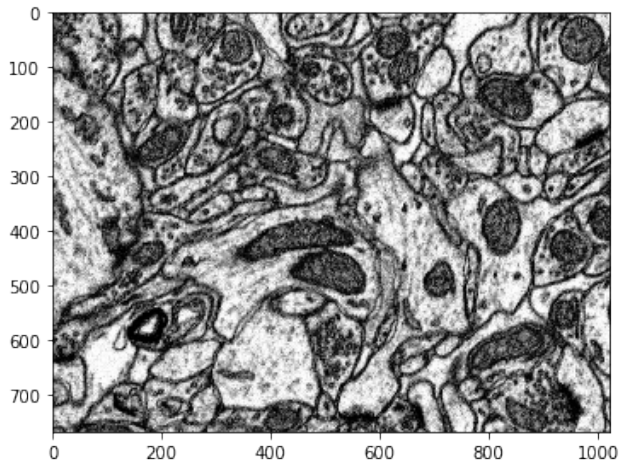
- Data Preprocess and Augmentation
- Unet Neural Network Structure
- Attention-Unet
- Results and Analysis
- Conclustion and Future Improvement

Data Preprocess

- Color correction by gamma correction $V_{out} = AV_{in}^{\gamma}$
- Contrast increment by histogram equalization



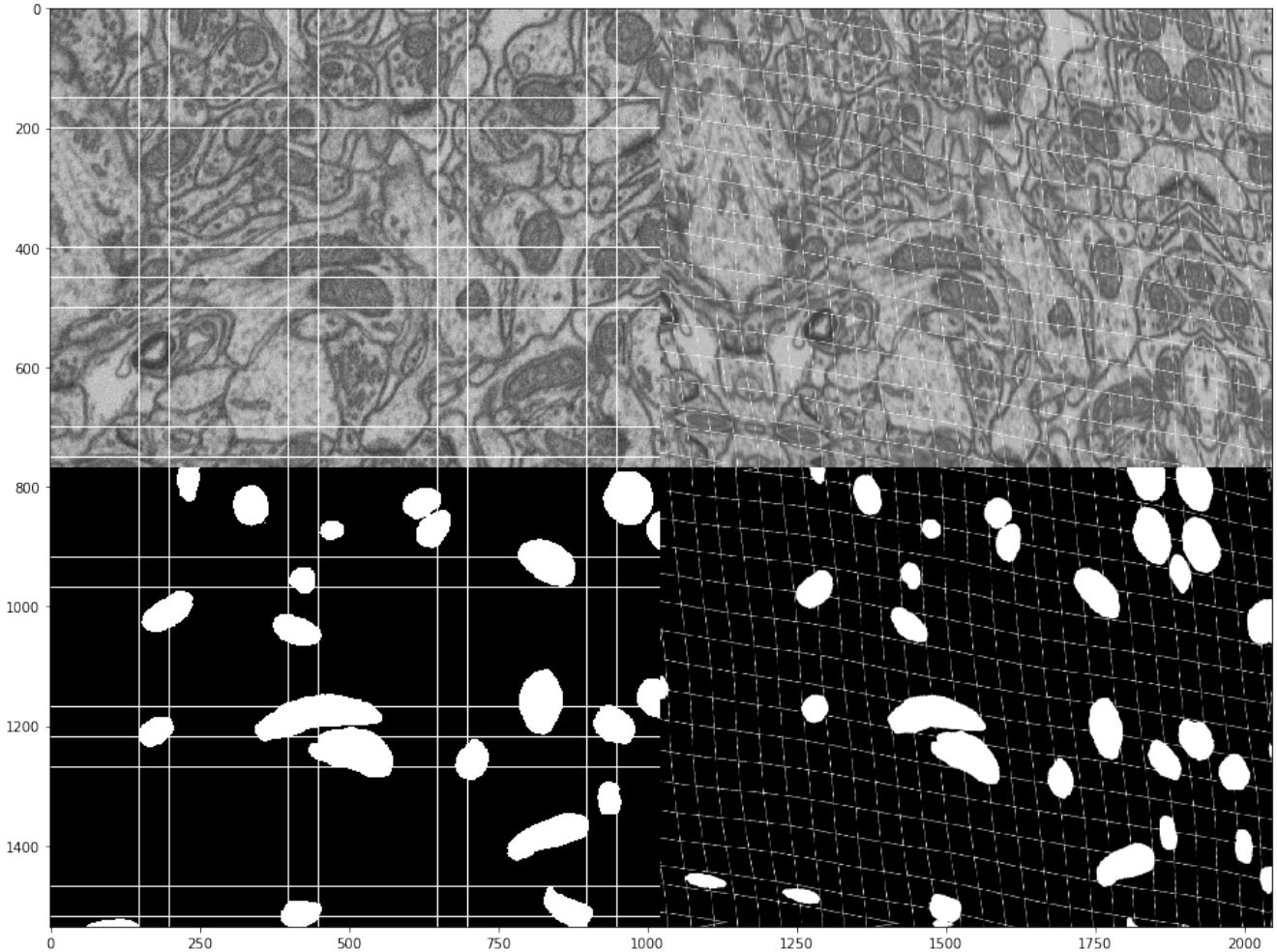
(a) Original EM Image



(b) Image after Preprocess

Data Augmentation

- Data Augmentation with flip, rotation, zoom, shift and elastic distortion.



The Unet Model

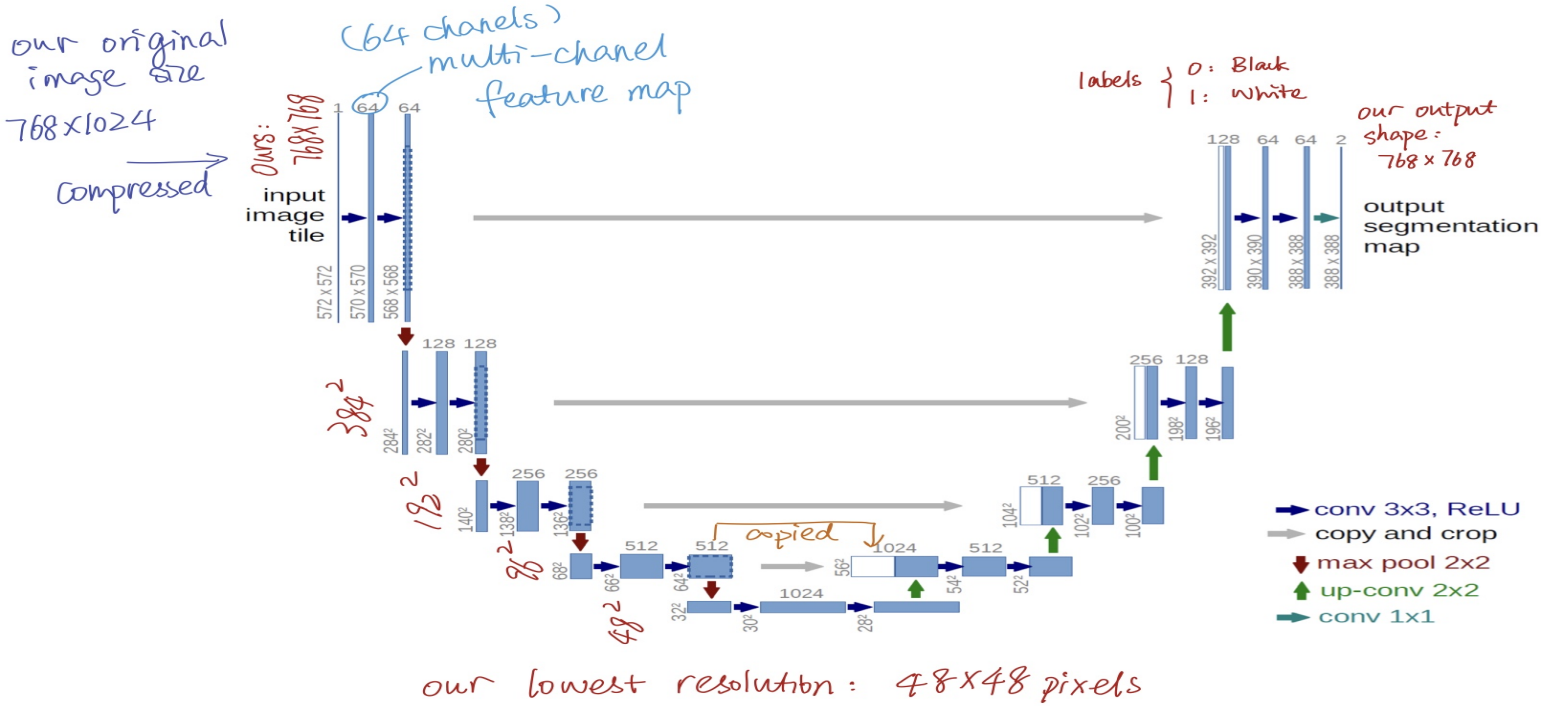


Figure: Unet Structure

- Large feature channels in upsampling: propagate context information to higher resolution layers.

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[1] Ronneberger, O., Fischer, P., Brox, T. (2015, October). U-net: Convolutional networks for biomedical image segmentation.

The Unet Model Objective Function

- Binary Categorical Loss

$$\text{Binary Loss} = -\frac{TP + TN}{TP + TN + FP + FN}$$

- Since the most of pixels in our mask label are black (0), and we obtain about 89 percent accuracy even if we predict all black, we are more interested in the TP value rather than TN.
- Dice Loss

$$\text{Dice Loss} = -\text{Dice Score} = -\frac{2 * TP}{2 * TP + FP + FN}$$

Attention Unet Model

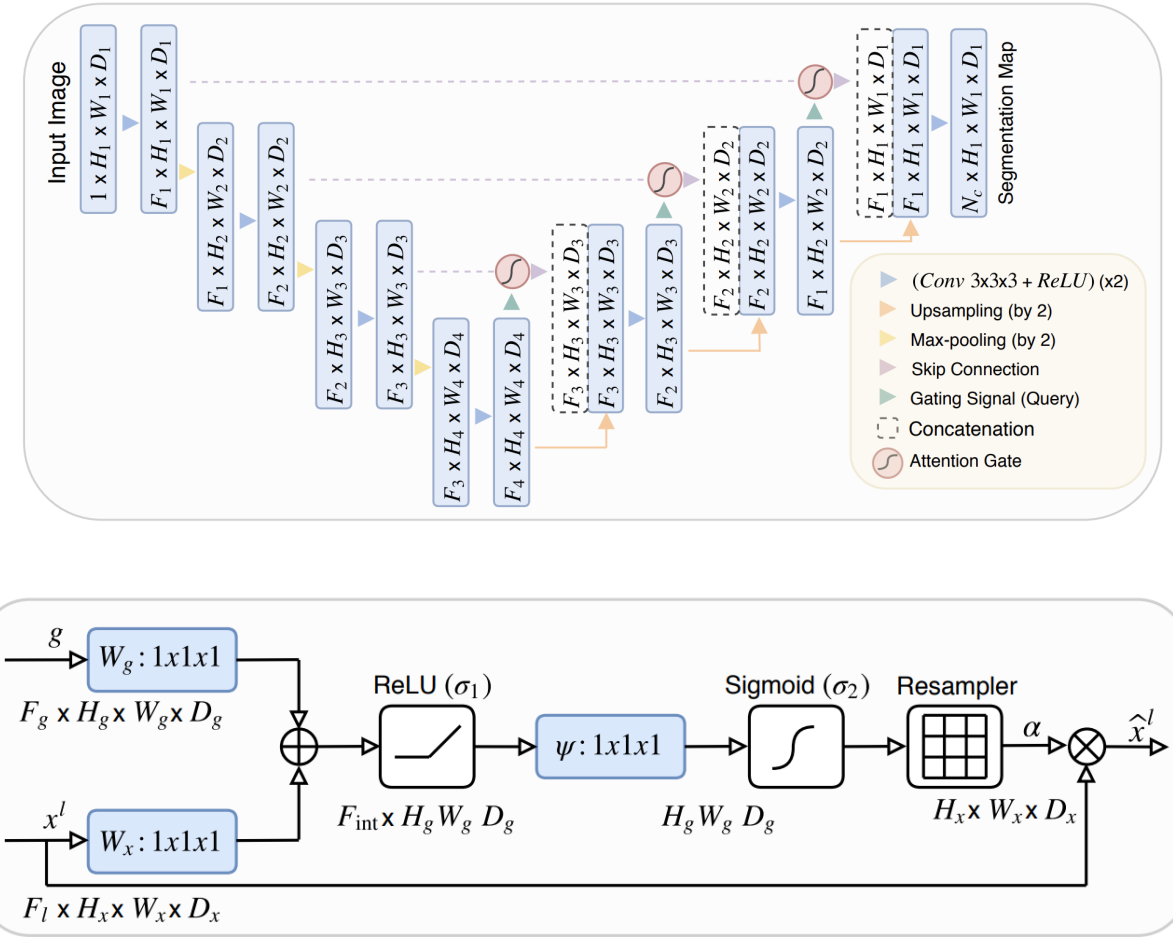


Figure: Additive Attention Gate (AG)

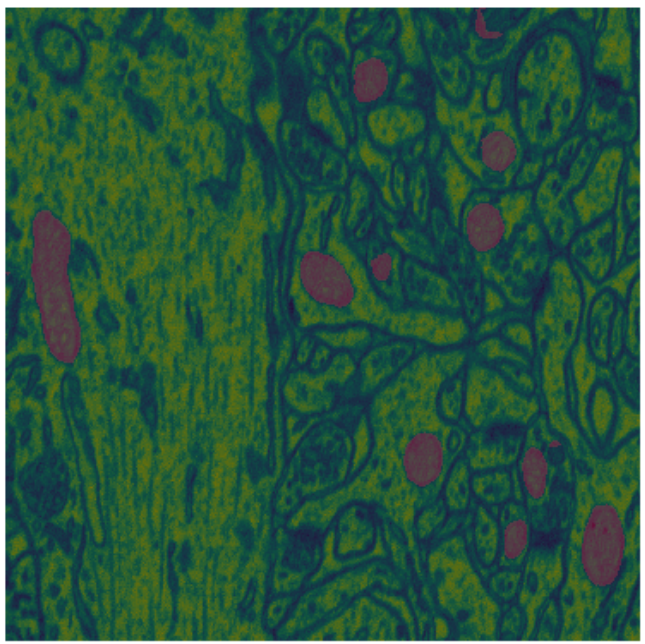
[2]Oktay, O.... (2018). Attention U-Net: learning where to look for the pancreas.

Our Results

- Quantitative Results

	Train Dice Score	Test Accuracy	Test Dice Score
Unet	0.8820	0.9213	0.4043
Attention Unet	0.9474	0.9225	0.4206

- Qualitative Results

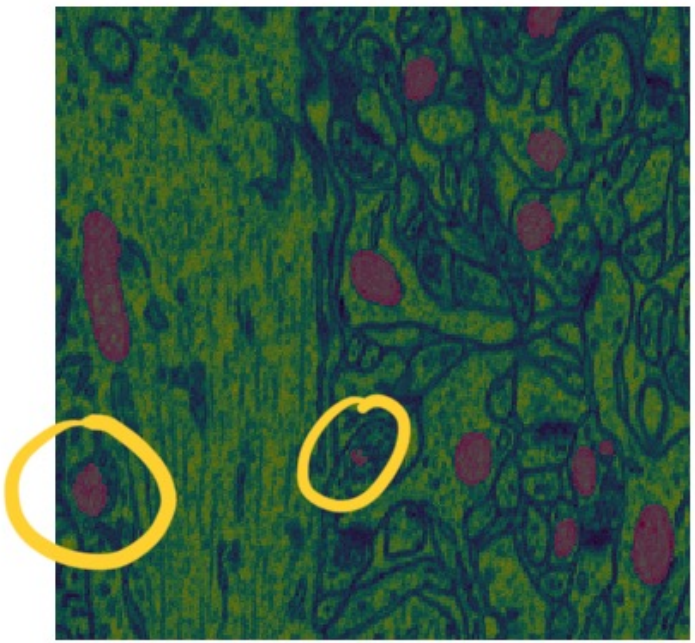


(a) Attention Unet Predict Mask

(b) Gold mask

Our Results

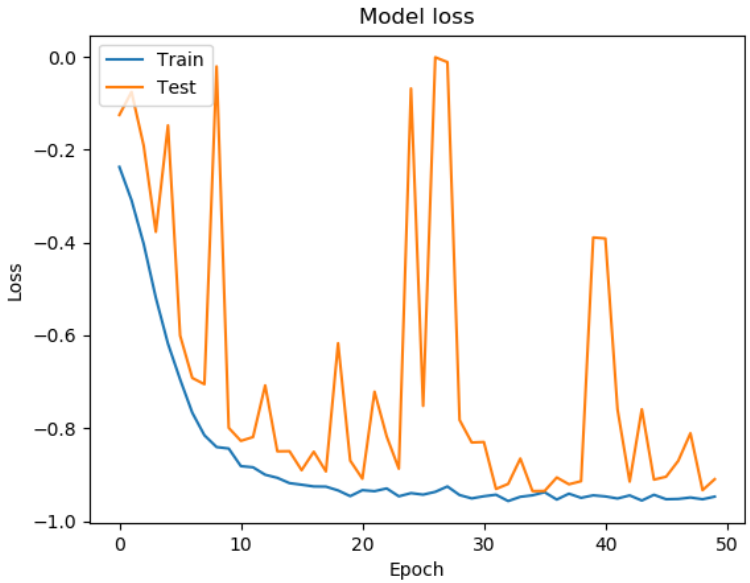
- Unet has a poor performance on distinguish between cell nuclear and mitochondria, while attention u-net is able to supress those irrelavant regions.



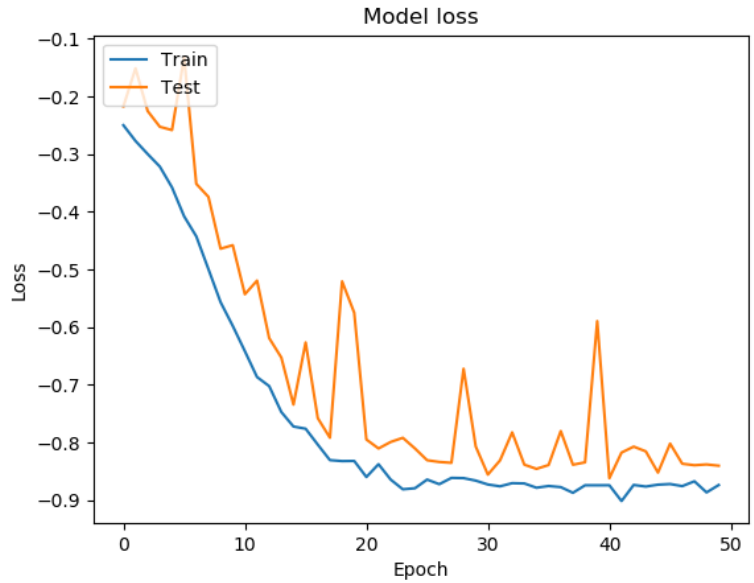
(a) Unet-Predict Mask

(b) Gold mask

Attention Unet Model



(a) Attention Unet Train & Validation Dice loss



(b) Unet Train & Validation Dice loss

Conclusion and Further Improvements

- Both models provide smooth border of the predicted masks, and has high test accuracy score. However, the test dice score is only half of the train even if we applied the normalization methods.
- The Attention U-net train loss converges faster than U-net, and obtains better results in both qualitative and quantitative aspects.
- Utilize super-pixel image preprocess method by simple linear iterative clustering (SLIC) method; "k-means" clustering of pixels