Pixel-wise Segmentation of Microscopy Images with Deep Learning

Filip Sawicki, Karl Ulbæk and Teun Huijben

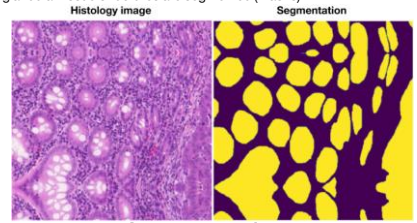
In collaboration with Peter Jensen

Introduction

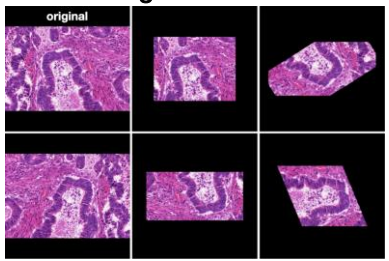
Current biomedical and industrial research depends heavily on doing optical microscopy, for diagnosing diseases, understanding fundamental cellular processes, and drug discovery. Image segmentation is vital to extract quantified measurements from microscopy images. To make the process of image segmentation faster, reliable general, and more automated, we will implement and validate multiple deep learning approaches.

Data

To test and validate our neural network approach, we will use the gland dataset [1]. This dataset was used in the Gland Segmentation in Colon Histology Images Challenge Contest (GlaS) held at MICCAI 2015. The dataset contains 168 histology images stained with Hematoxylin and Eosin, in which the glandular tissue structures are segmented (masks).



Augmentations



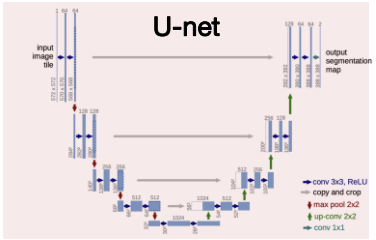
References:

[1] K. Sirinukunwattana, *et al.* "A Stochastic Polygons Model for Glandular Structures in Colon Histology Images," in IEEE Transactions on Medical Imaging, 2015

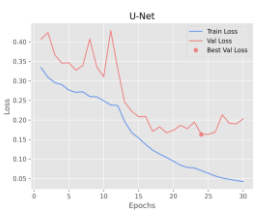
[2] Ronneberger, Olaf, *et al.* "U-net: Convolutional networks for biomedical image segmentation." *International Conference on Medical image computing and computer-assisted intervention*. Springer, Cham, 2015.

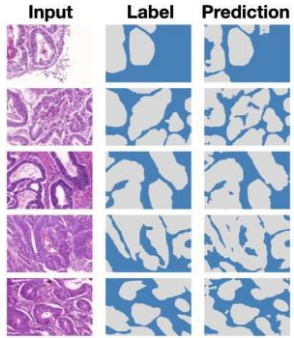
[3] He, Kaiming, *et al.* "Mask r-cnn." *Proceedings of the IEEE international conference on computer vision*. 2017.

Convolutional Neural Network (CNN)



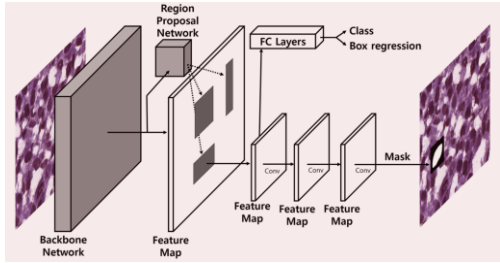
Results



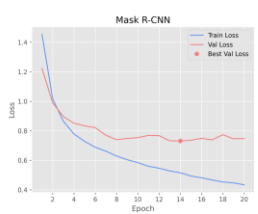


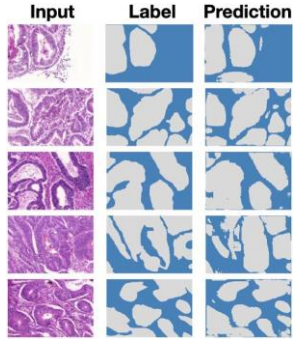
	test A (60 images)	test B (20 images)
F1	0.86	0.90
Object F1	0.81	0.86
Hausdorff	69.8	69.8

Mask R-CNN



Results





	test A (60 images)	test B (20 images)
F1	0.83	0.85
Object F1	0.78	0.81
Hausdorff	37.1	65.0

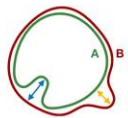
Metrics

- **F1-score** = $\frac{\text{overlap}}{\text{union}} = \frac{2}{}$

- **Object Hausdorff** =

$$\max\left(\max_{a\in A}\min_{b\in B}\|a-b\|, \max_{b\in B}\min_{a\in A}\|a-b\|\right)$$

- **Object 1-score** = F-1 per object



Discussion

We can conclude that both our U-net and Mask R-CNN implementations are able to correctly segment the glandular tissue structures in histological microscopy images. We hypothesized that Mask R-CNN would outperform U-net, however, U-net has a slightly better performance compared to Mask R-CNN. This can probably be improved by a more elaborate choice of hyperparameters. Next to that, we concluded from visual inspection of the predicted segmentations, that U-net performs better in the case of large tissue patches, where Mask R-CNN performs better for many equal-sizes smaller tissue patches.