Image Analysis for High-Throughput Microscopy Screening

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Project Outline

- Problem: Cell segmentation and annotation in microscopy images is very costly and time consuming
- Solution: Automatic segmentation using neural networks
  - Previously done using a U-Net
  - New approach: Using a HoVer-Net
- Challenges:
  - Limited labeled data
  - Segment borders can be unclear
  - Overlapping cells

Methods

Data

Model

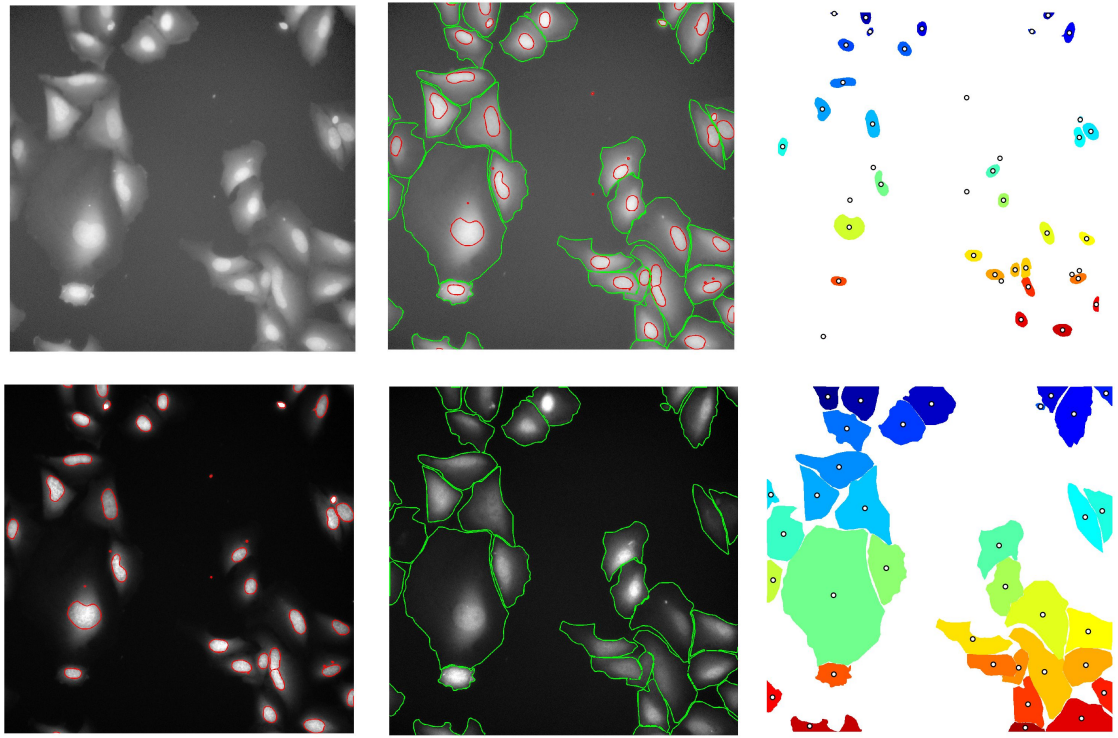
Training

Prediction

Evaluation Metrics

Data

1104x1104 pixels grayscale images, split into 80x80 patches



Nuclei data

- 44 train images, 6 test images

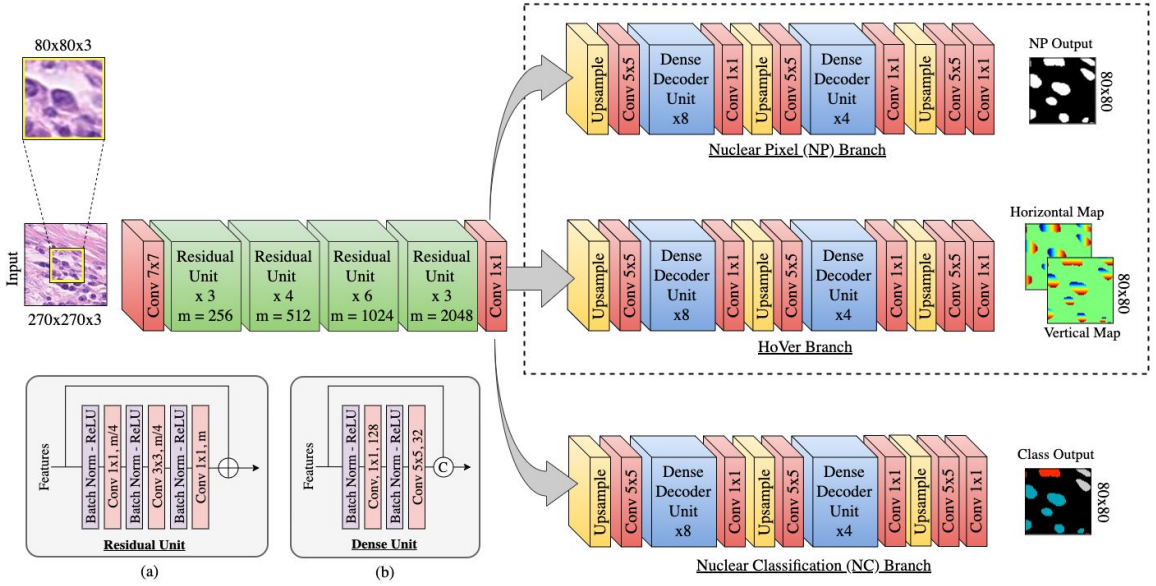
Cell data

- 22 train images, 5 test images

Model

HoVer-Net

- Published in 2019 by Graham, Simon et al.
- Specifically designed for instance segmentation (and classification) in medical cell images
- One encoder, three decoder branches



Training, Prediction, Evaluation

- Preprocessing of data and conversion with MATLAB
- Transfer learning: Checkpoint with pretrained HoVer-Net on external data set
- Network Parameters:
  - Learning Rate: 0.0001
  - Epochs: 1-50
  - Optimizer: Adam
  - Loss function: Combined pixel-based regression loss, weighted for each branch
- Evaluation:
  - Pixel-based approaches
  - Object based approaches: F1-Score, Jaccard Index

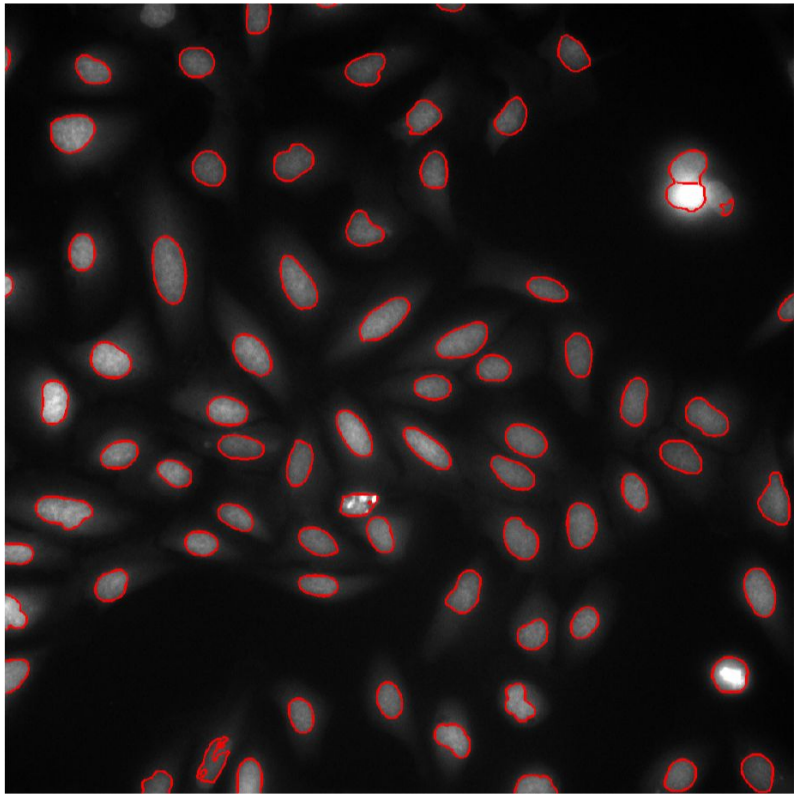
Results

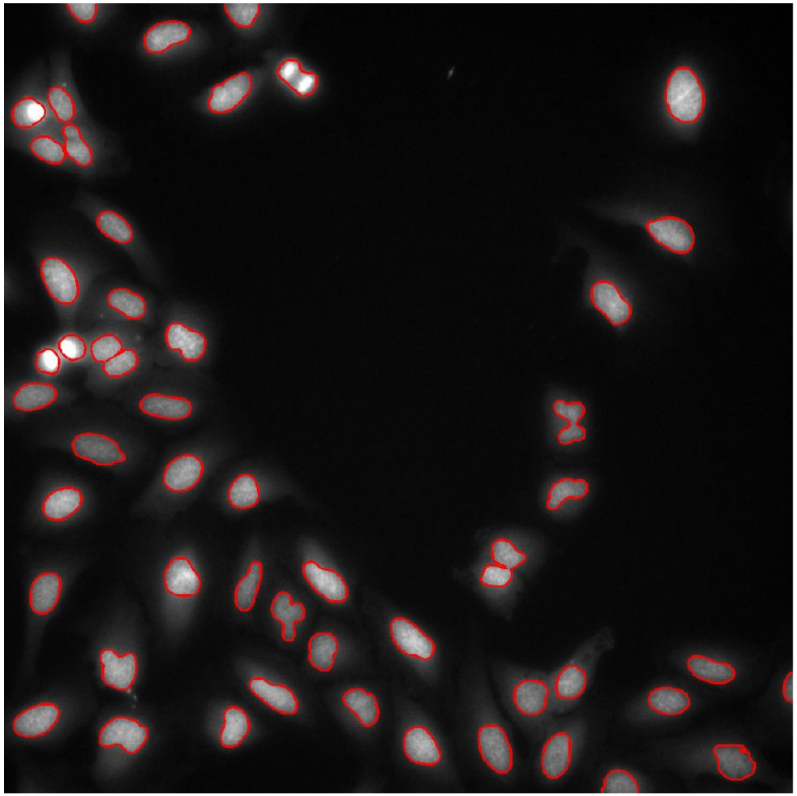
Nuclei Segmentation

Cell Segmentation

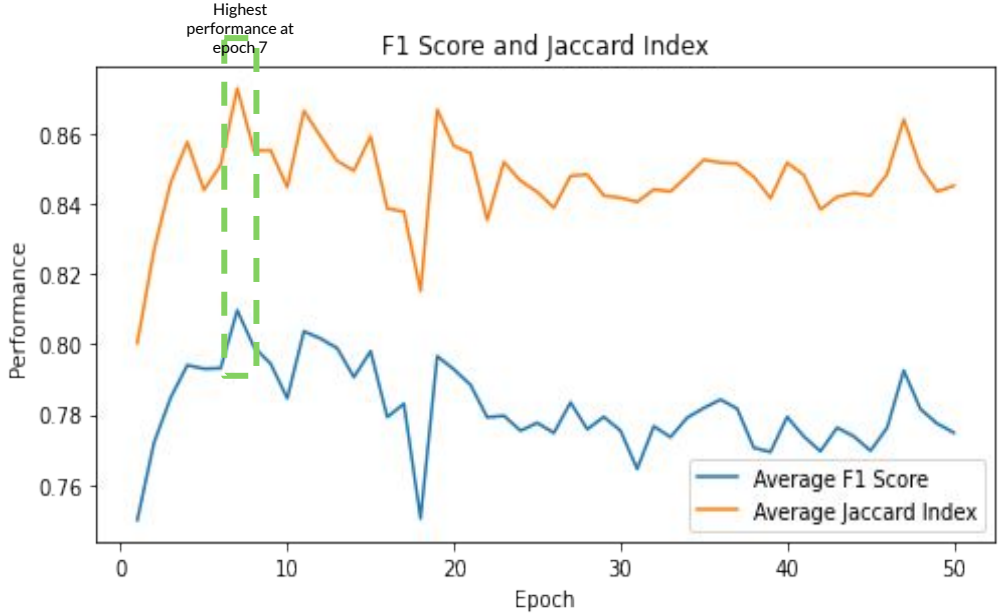
Nuclei Segmentation

Results on validation data using our best model



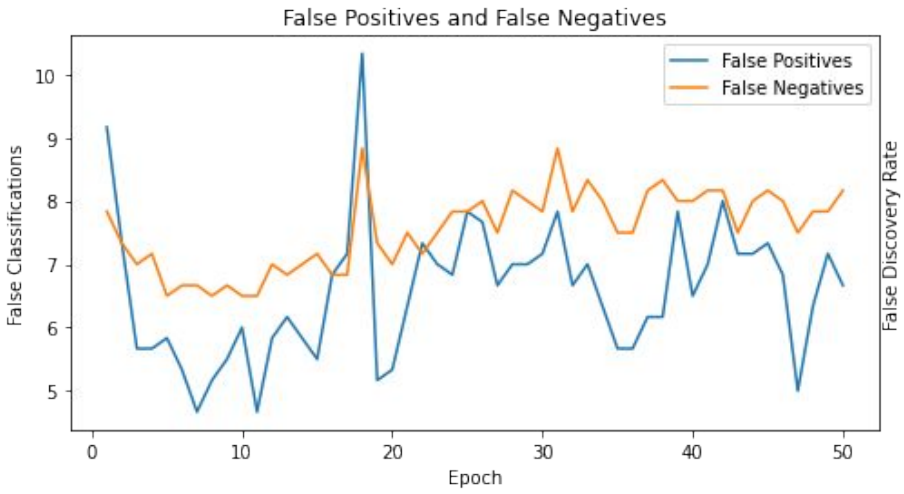


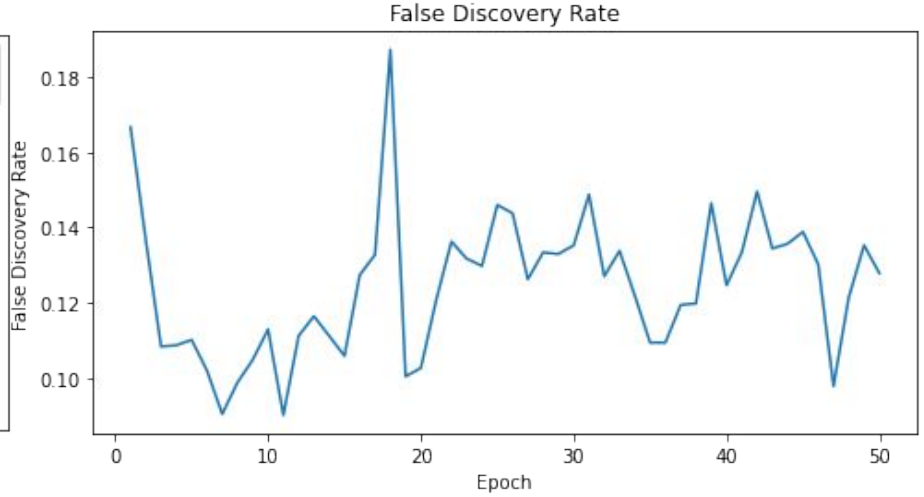
Nuclei Segmentation



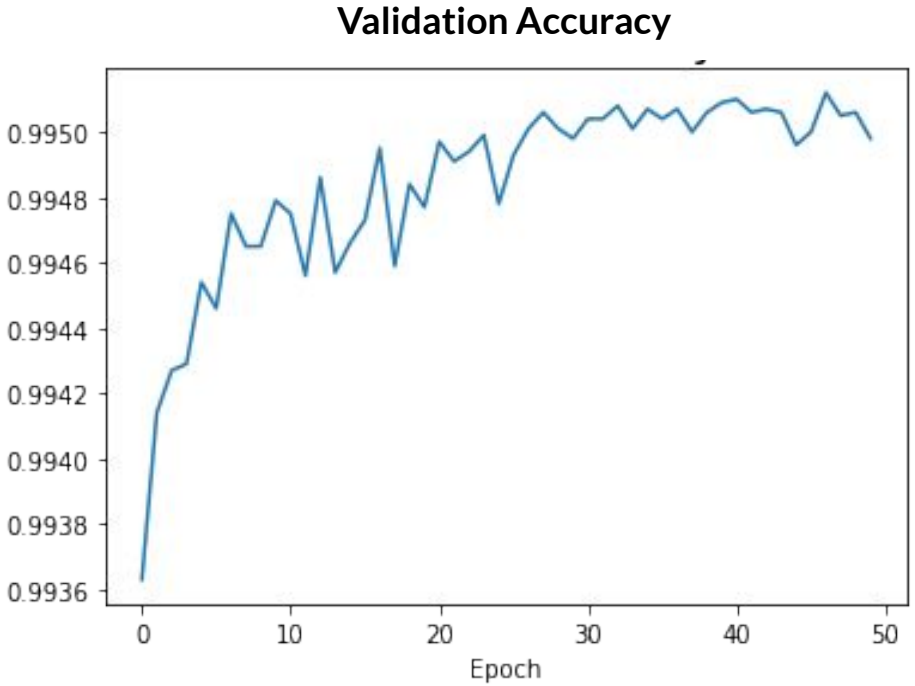
	F1 Score with 0.9 Threshold	Average F1 Score	Average Jaccard Index
HoVer-Net	74.7 %	80.4 %	87.3 %
U-Net	65.4 %	78.2 %	86.9 %

Nuclei Segmentation



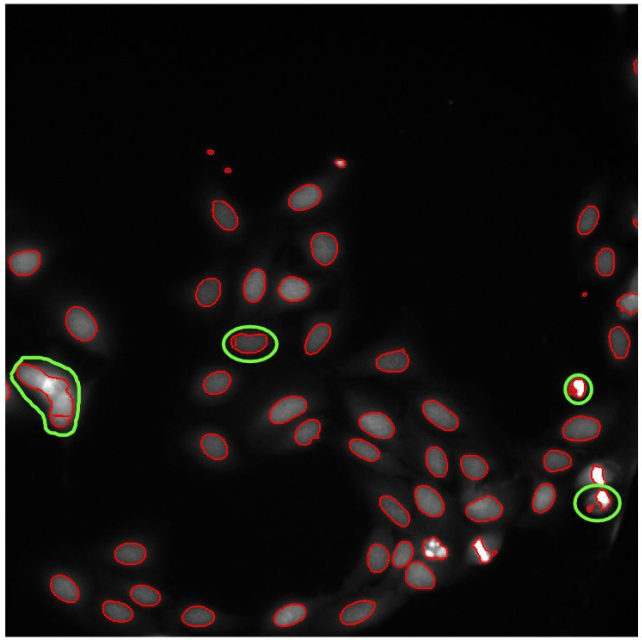


Nuclei Segmentation

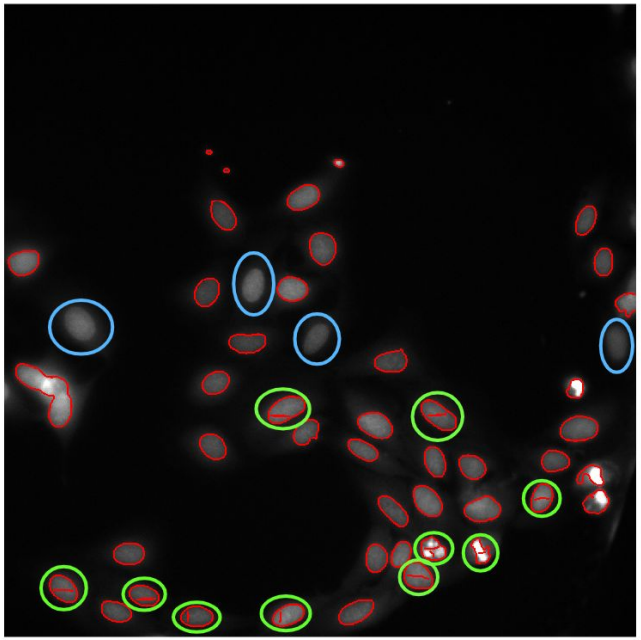


Nuclei Segmentation

Epoch 7



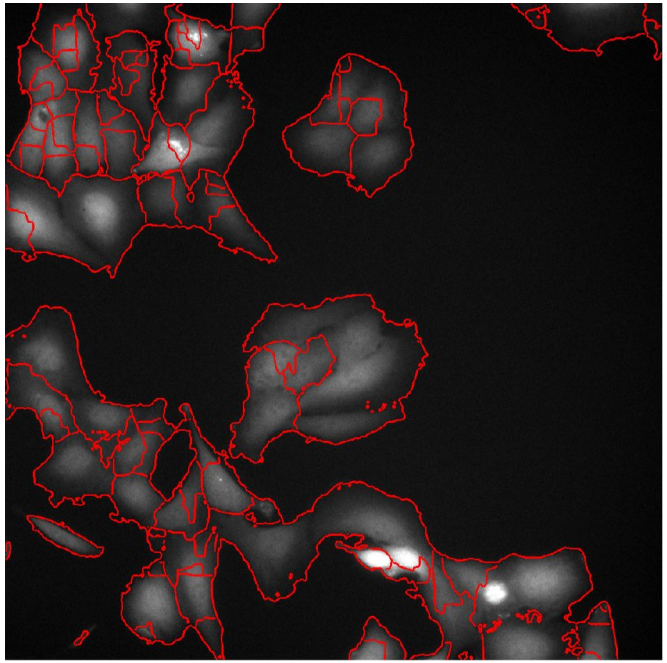
Epoch 50



Red : Predicted Segments
Green : false positives, incorrect merges or splits
Blue : false negatives

Cell Segmentation

- Oversegmentation seen with pre-trained weights
- Fine-tuning did not solve oversegmentation



Conclusion

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- Promising results for the nuclei segmentation
- Quick overfitting, after seven epochs
- Pixel-based error functions and metrics during the network training should be changed to object-based approaches
- More data is needed to properly train and evaluate the network’s performance

Questions?