AoE/BME Project

Cell Segmentation With U-Net.

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Friday December 9th, 2022

Cell Segmentation with U-Net

Background & Problem

Background

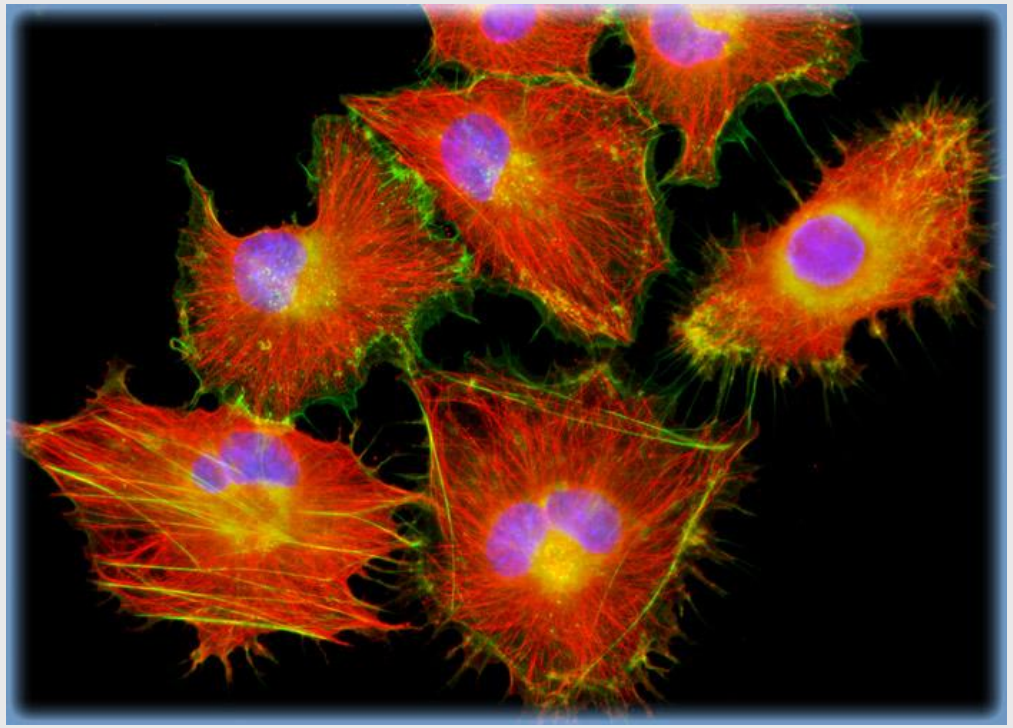
- Fast and efficient cell identification and segmentation has become important in attempts to explore the role of cellular heterogeneity in dynamic living systems.
- Manual methods of cell segmentation are tedious, time consuming and prone to more errors
- The advancement of machine learning is providing an efficient approach to cell segmentation.
- This project creates and trains a deep learning neural network, U-Net, to perform cell segmentation.

Cell Segmentation with U-Net

Data Acquisition

Data Acquisition

- This project uses fluorescence widefield microscopy images of nuclear and cytoplasmic live-cell stains of baby hamster kidney (BHK) cell cultures.

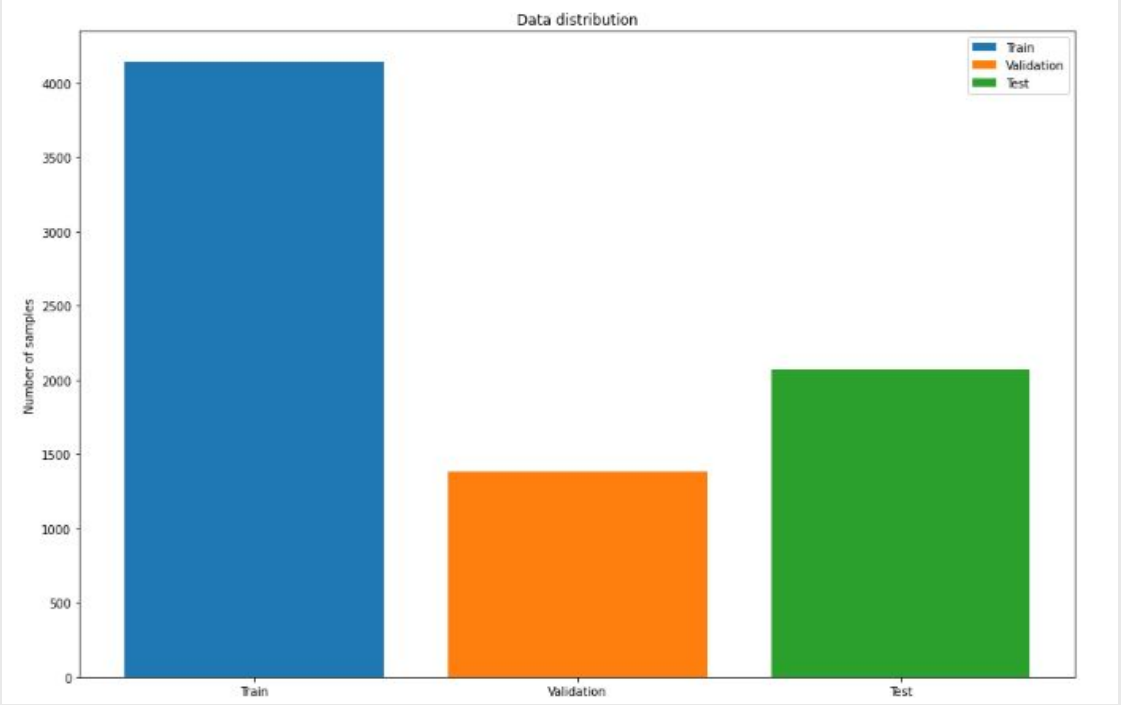


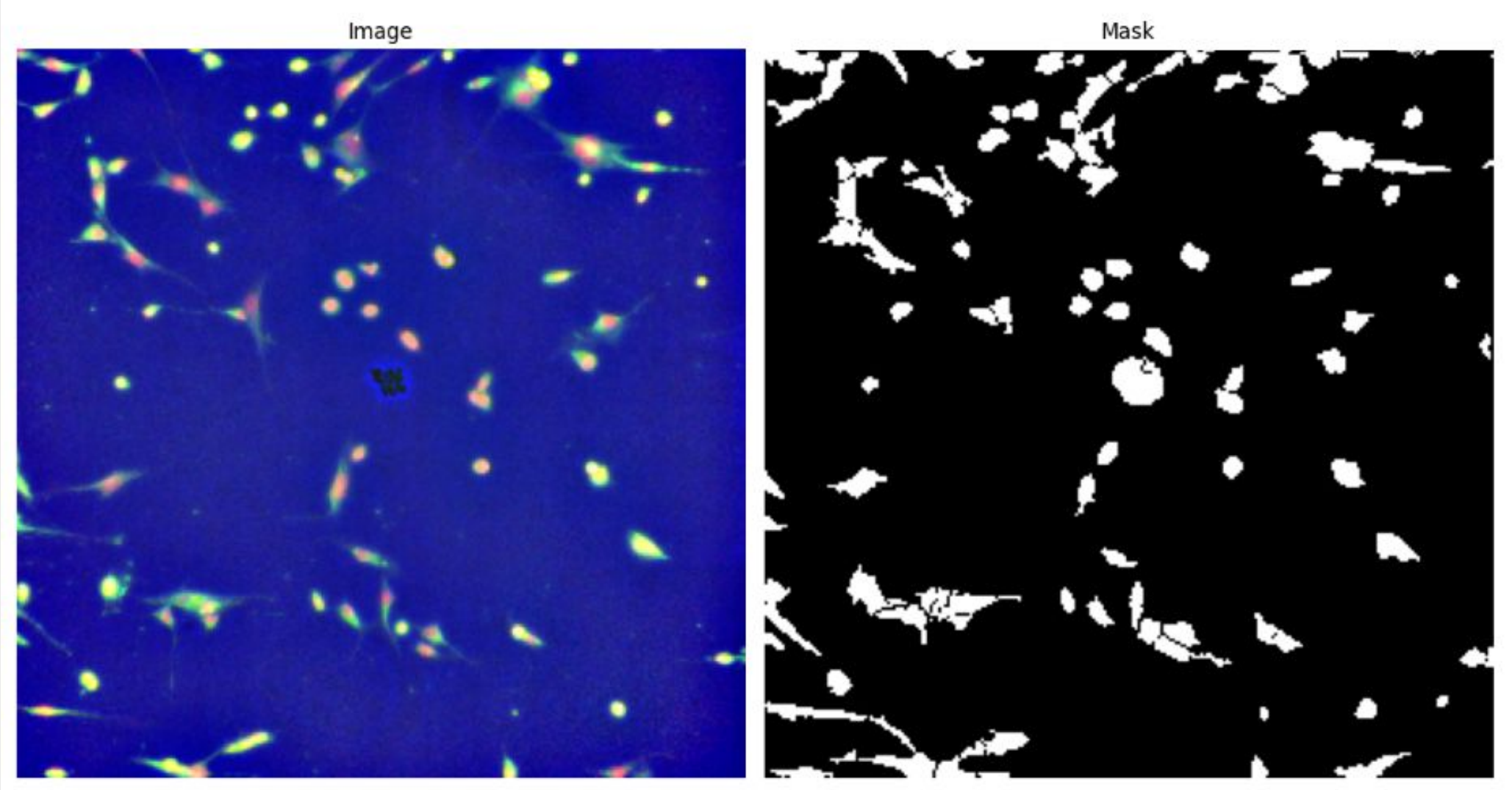
Dataset

Dataset

- The entire model makes use of 7590 samples divided into three different sets: Validation, Testing & Training datasets in the ratio 1 : 1.5 : 3
- Training dataset has 4140 samples
- Validation dataset has 1380 samples
- Testing dataset has 2070 samples
- Each sample consists of an image

and a corresponding image mask

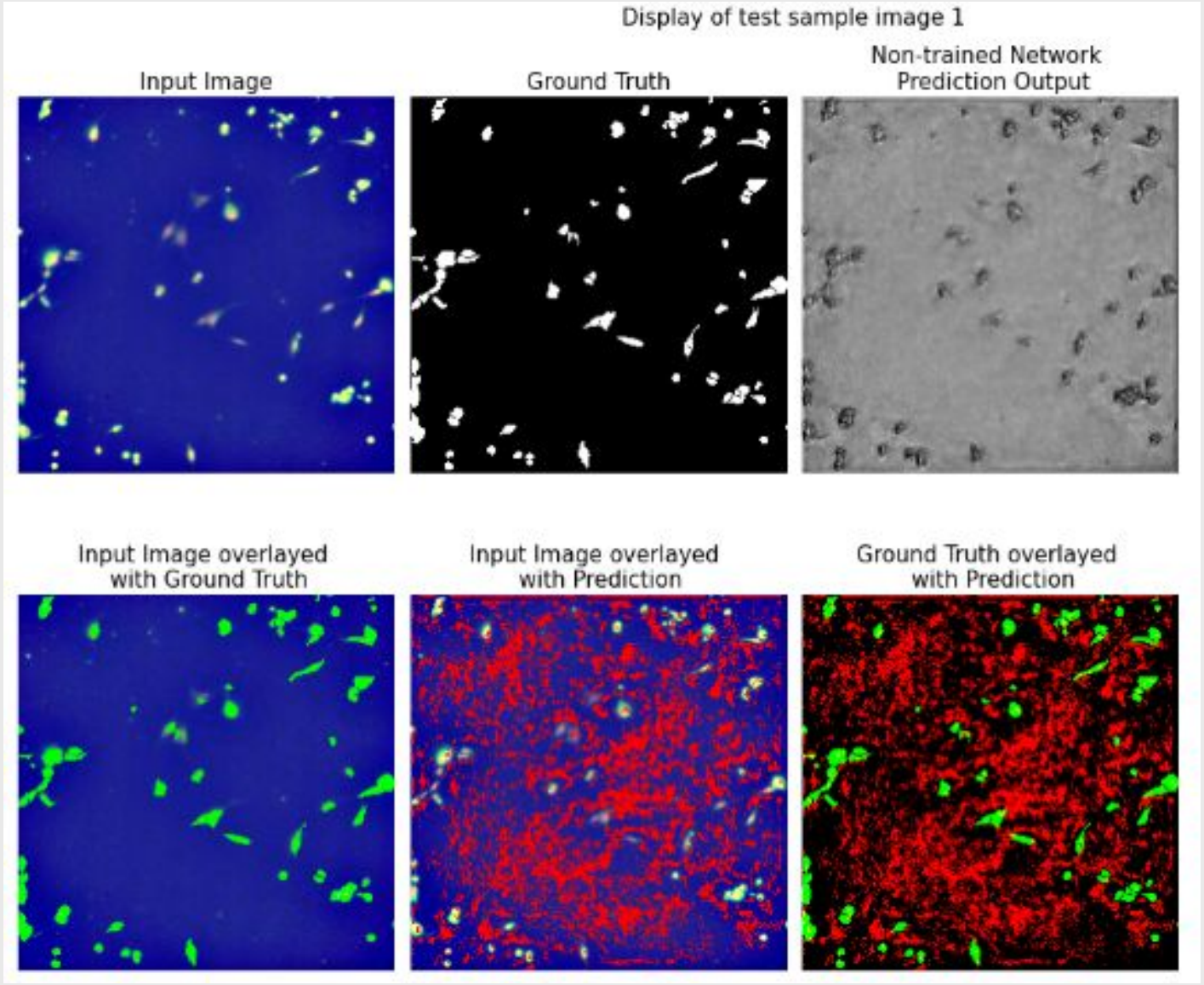




Sample image and corresponding mask

Cell Segmentation with U-Net

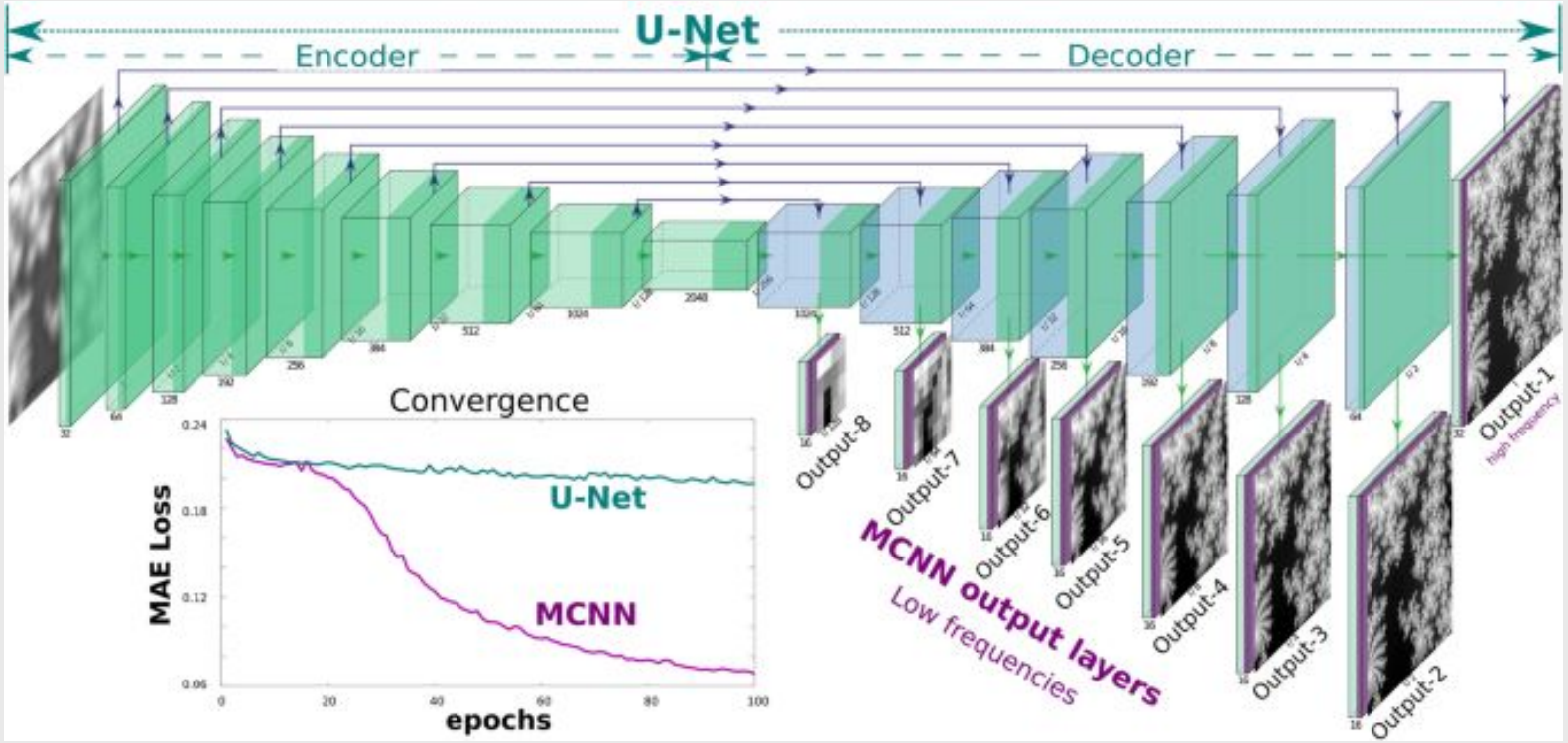
Approach



Prediction from untrained model

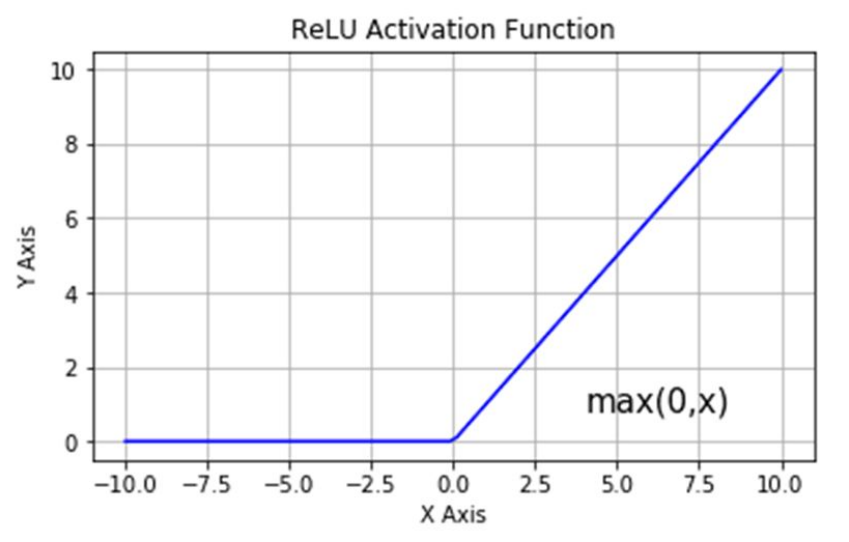
Approach

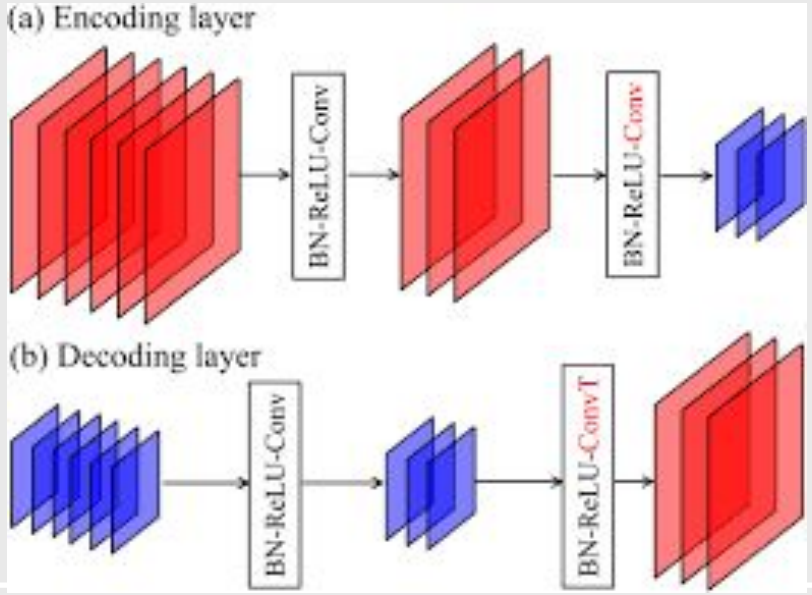
- U-Net consisting of convolutional layer, pooling layers and a fully connected layer



Approach

- The 2D convoluted layers are produced with kernel of size 3 and padding of 1. ReLU as the activation function applied to outputs
- Model had 4 encoding and decoding layers respectively





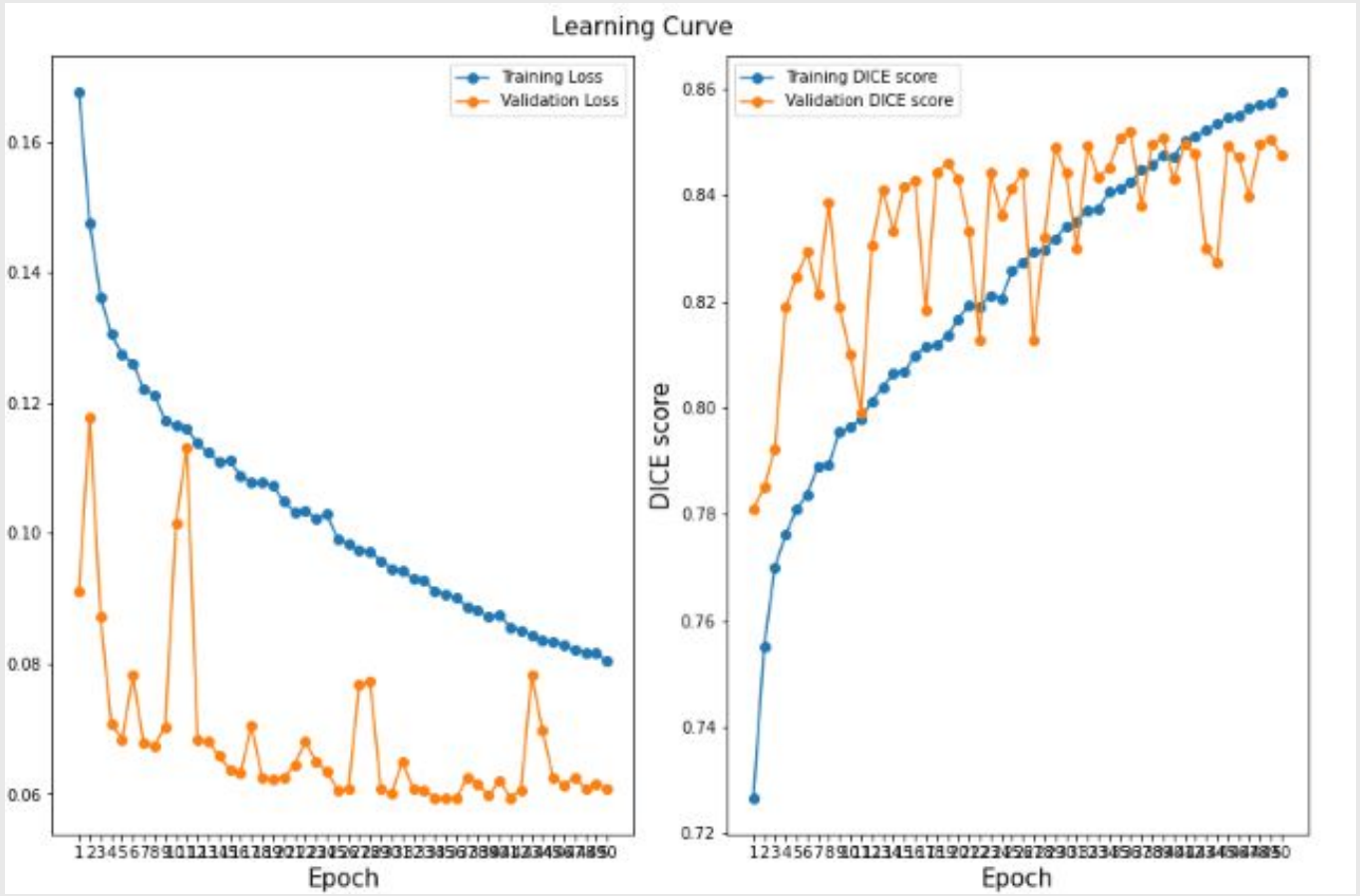
Approach

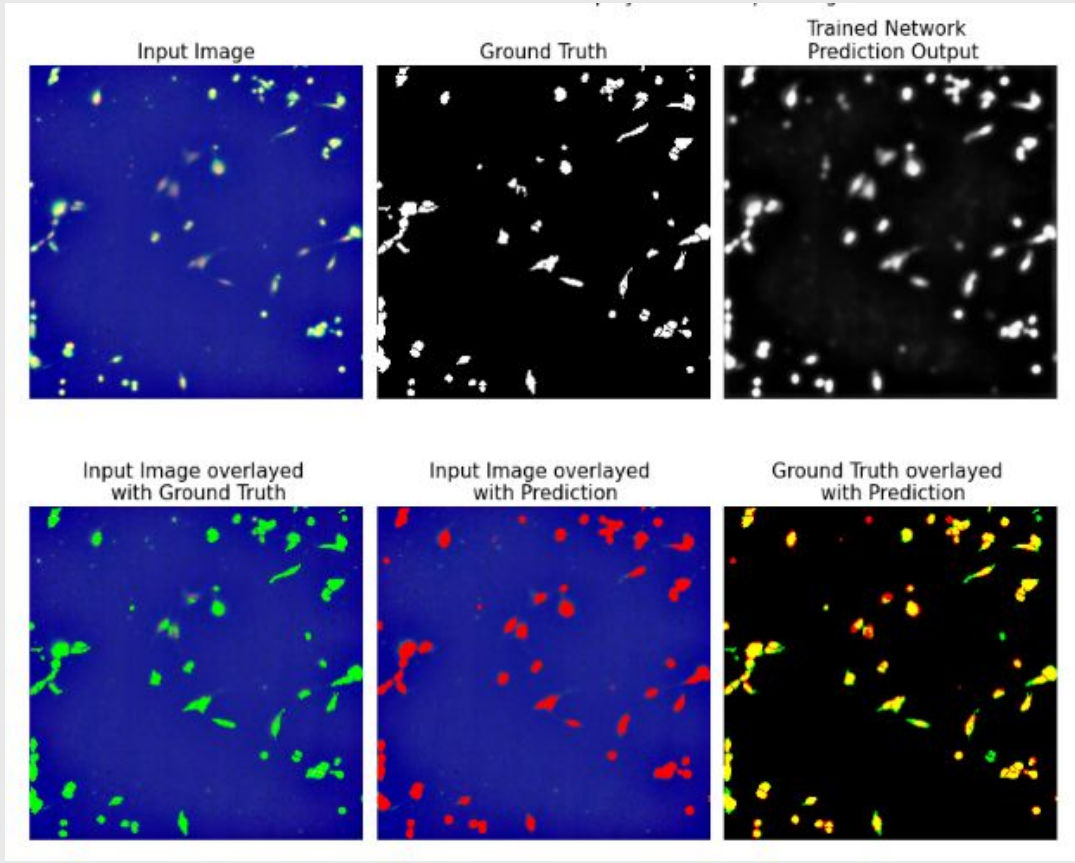
- U-Net used a Binary Cross-Entropy (log) loss function since this project is a binary classification method. A Categorical Cross-Entropy loss function wasn't optimal since this cell segmentation method has only two classes.
- Utilized the ADAM optimization algorithm since it's the most efficient method and is a combination of Adadelta, RMSProp and Adagrad.
- Training in batches for 50 epochs and used weights from the best epoch (highest validation DICE score) to finalize the model

Cell Segmentation with U-Net

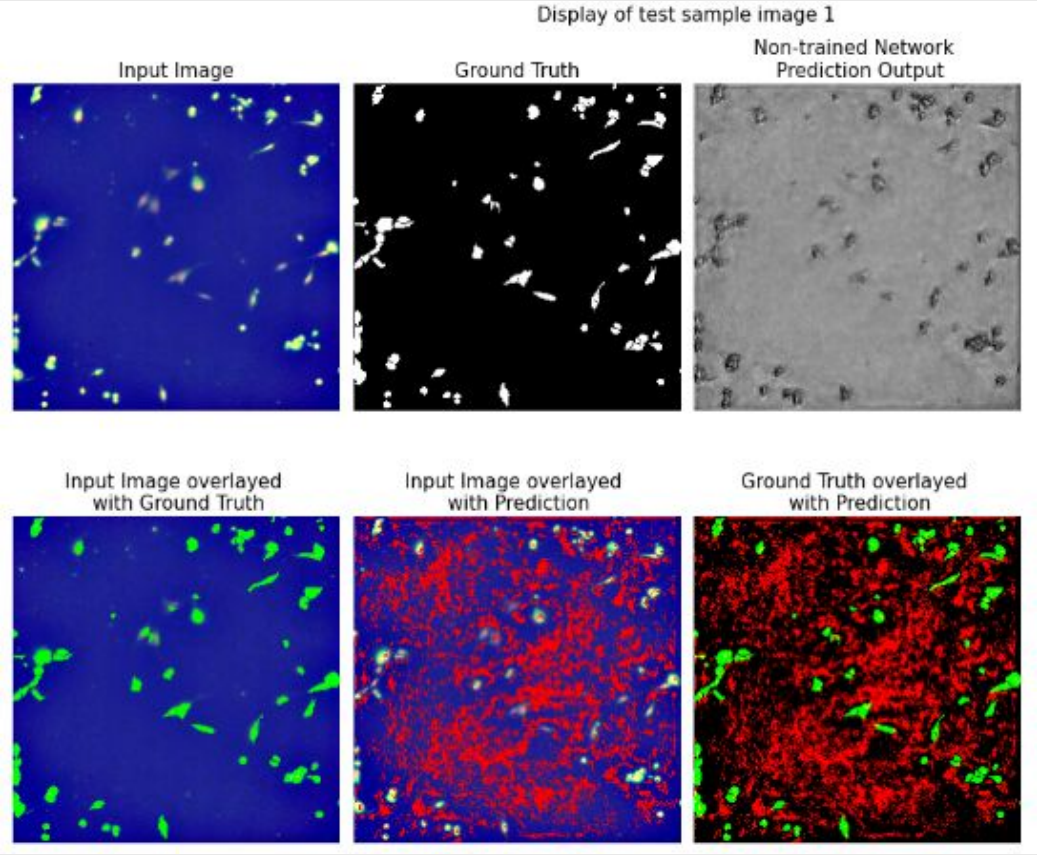
Results

Results

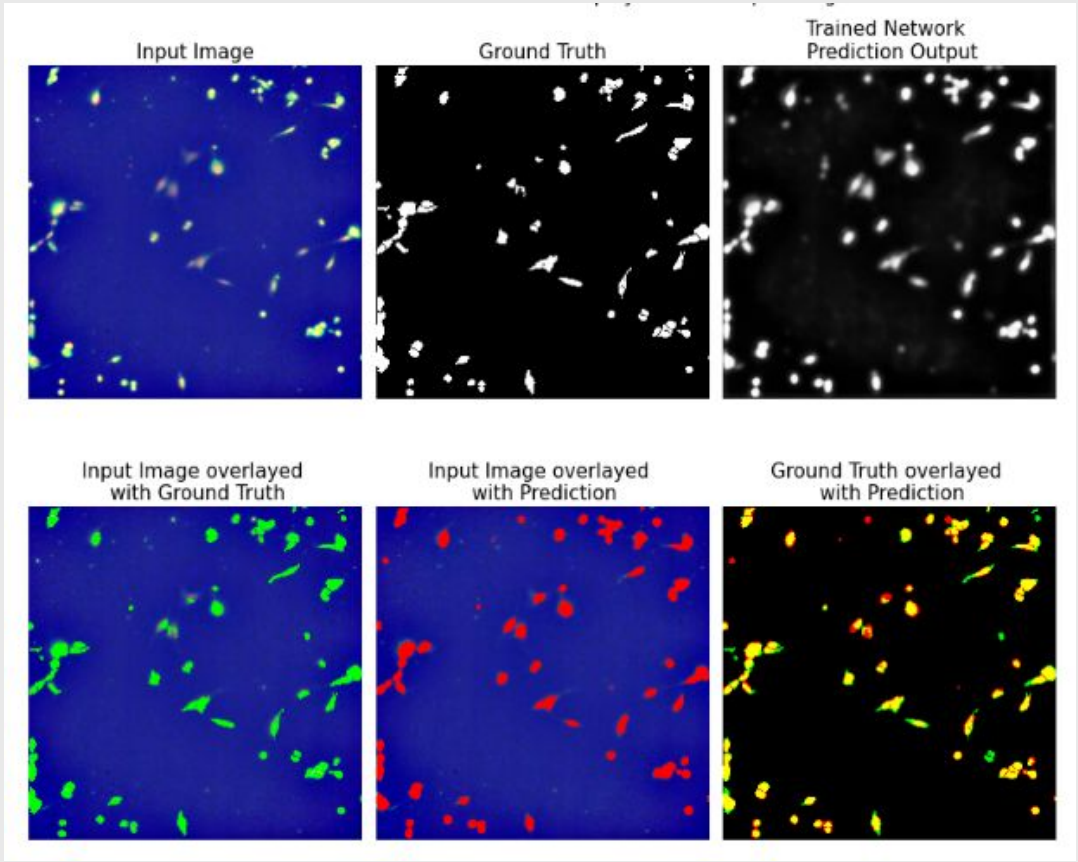

Learning Curve
Training Loss
Validation Loss
Training DICE score
Validation DICE score
DICE score
Epoch
Epoch


Input Image
Ground Truth
Trained Network
Prediction Output
Input Image overlayed
with Ground Truth
Input Image overlayed
with Prediction
Ground Truth overlayed
with Prediction

Results

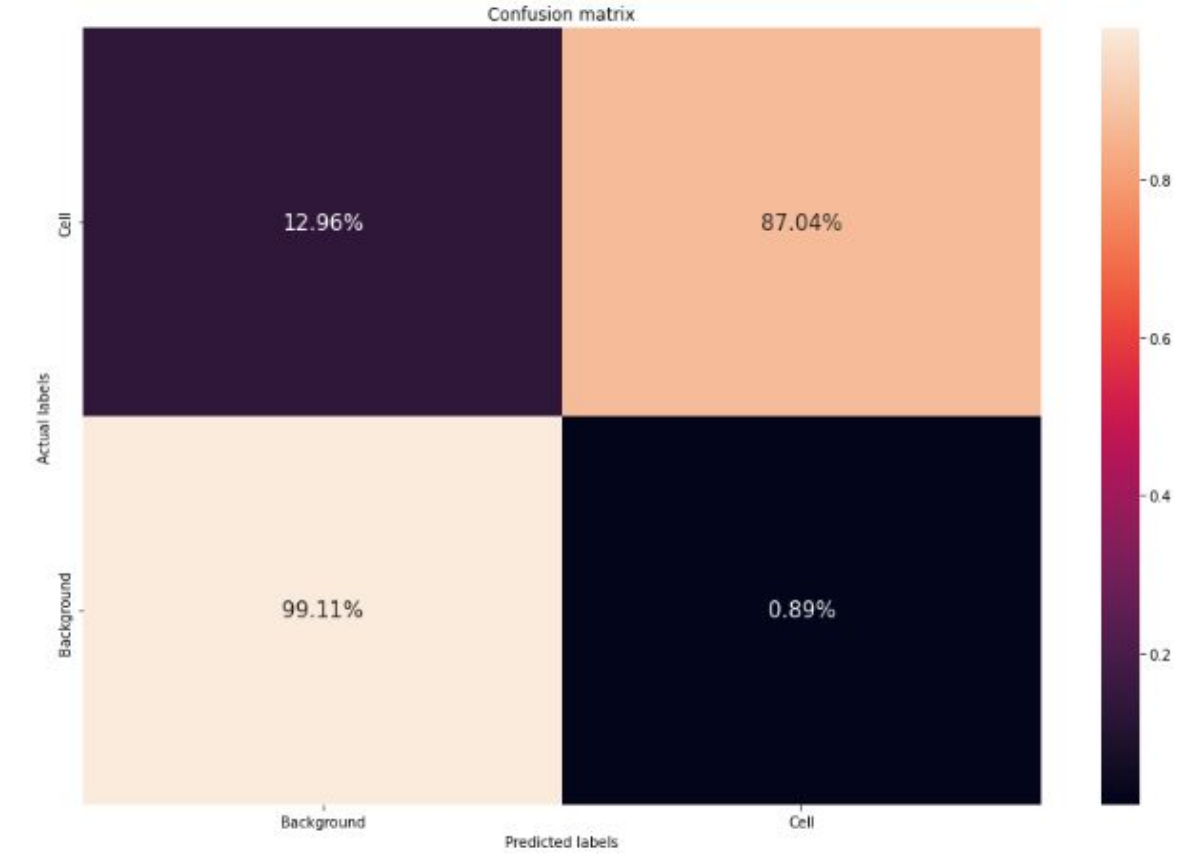


Prediction from untrained model



Prediction from trained model

Results



Prediction from untrained model

Cell Segmentation with U-Net

Method of improvement

Method of improvement

- Improved network design:
  - Increased kernel size to 5 and padding to 2
  - Increased number of encoding and decoding layers to 5 each