



# Cell Nucleus Segmentation

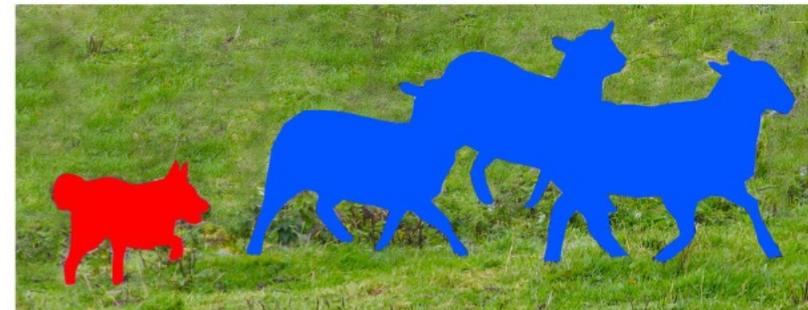
Bio394 Project

Ronald Domi

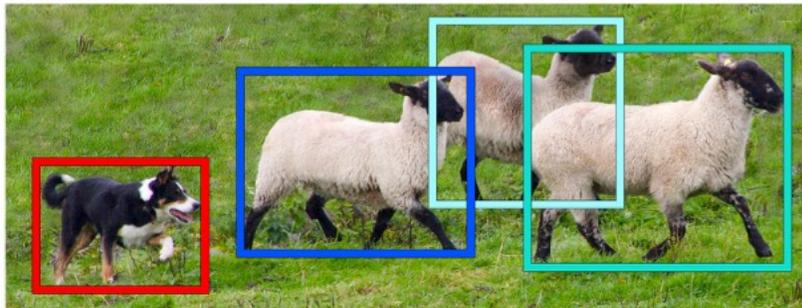
# What is Image Segmentation



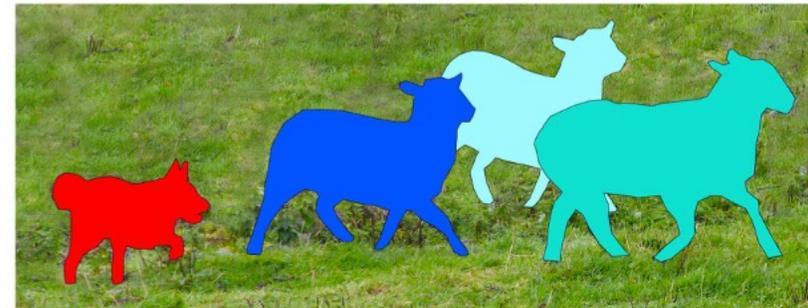
Image Recognition



Semantic Segmentation

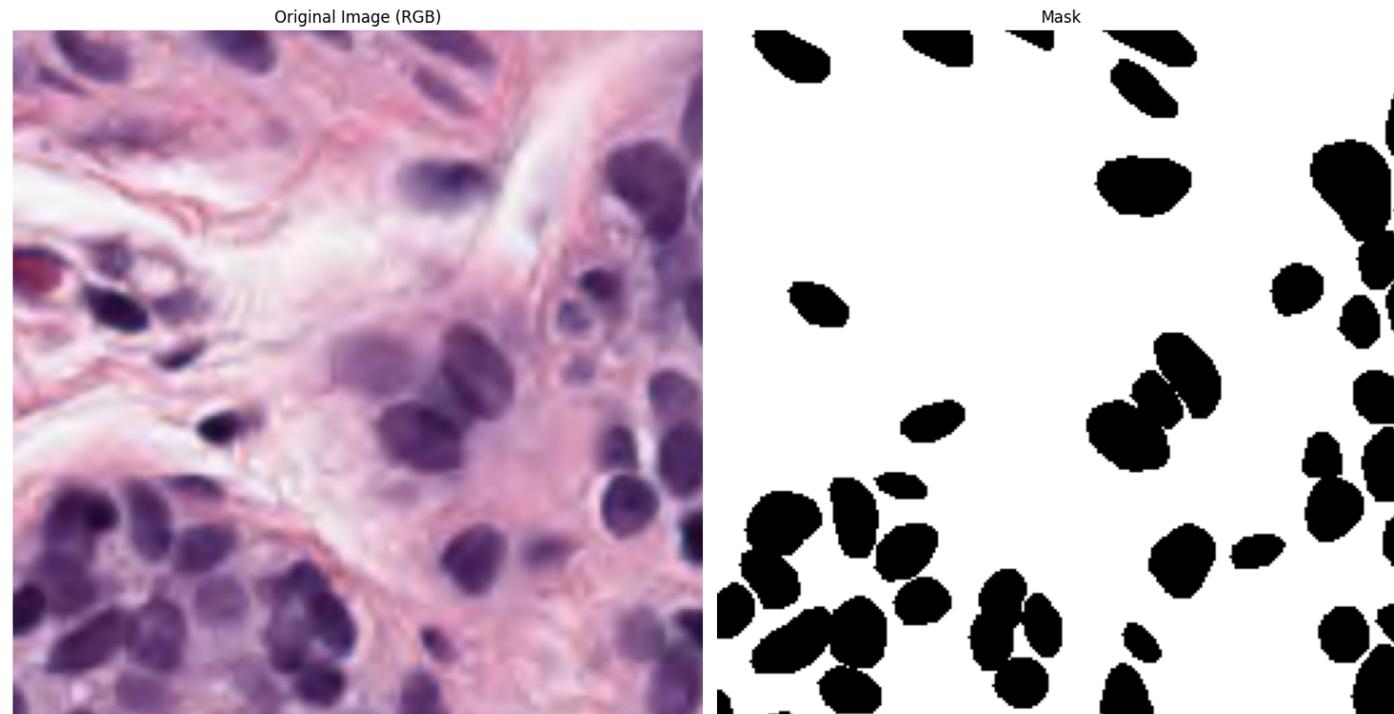


Object Detection



Instance Segmentation

# What we are working with



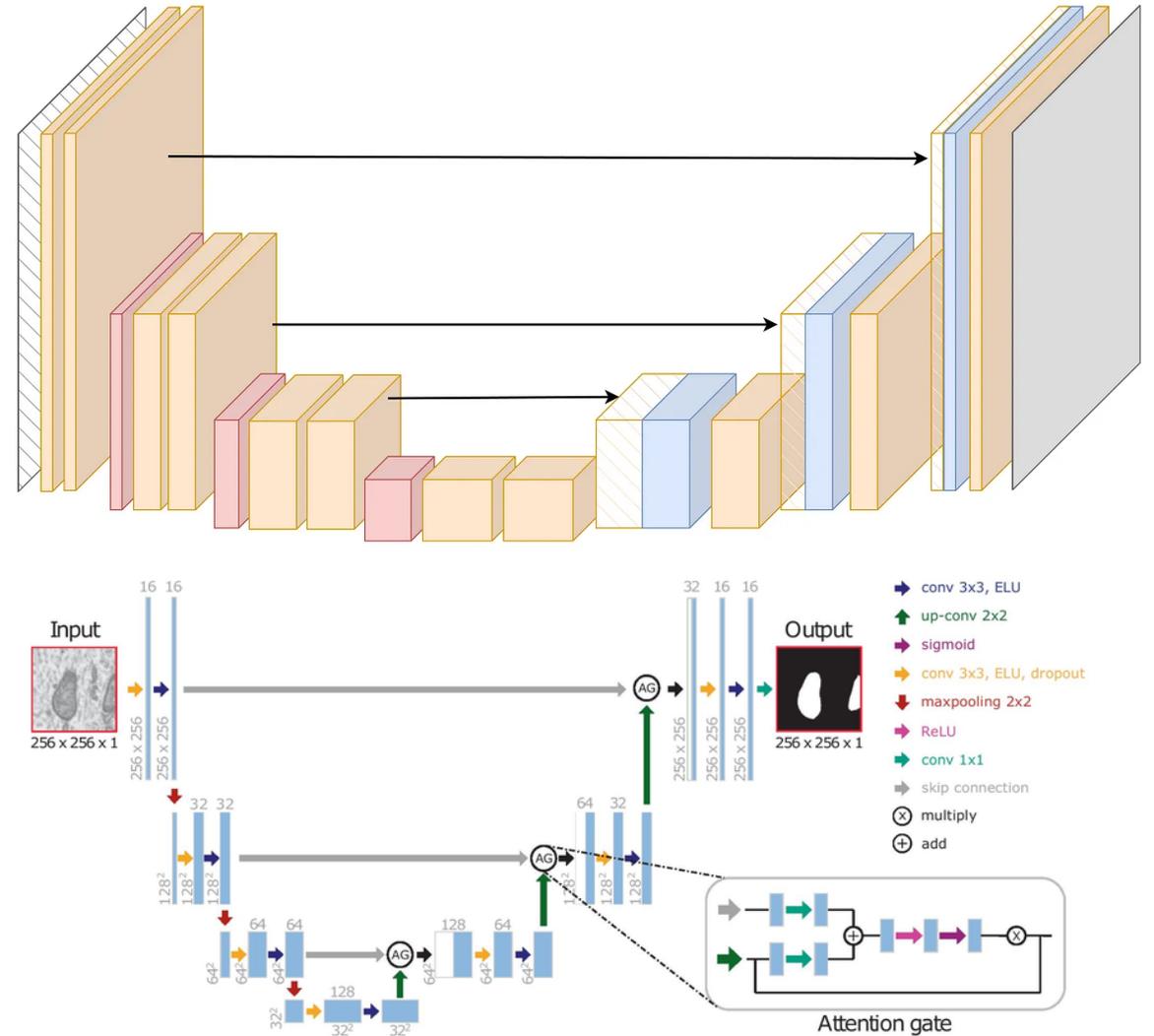
19 Tissue type

Source: [https://link.springer.com/chapter/10.1007/978-3-030-23937-4\\_2](https://link.springer.com/chapter/10.1007/978-3-030-23937-4_2)

# What we are training

## Two image segmentation models

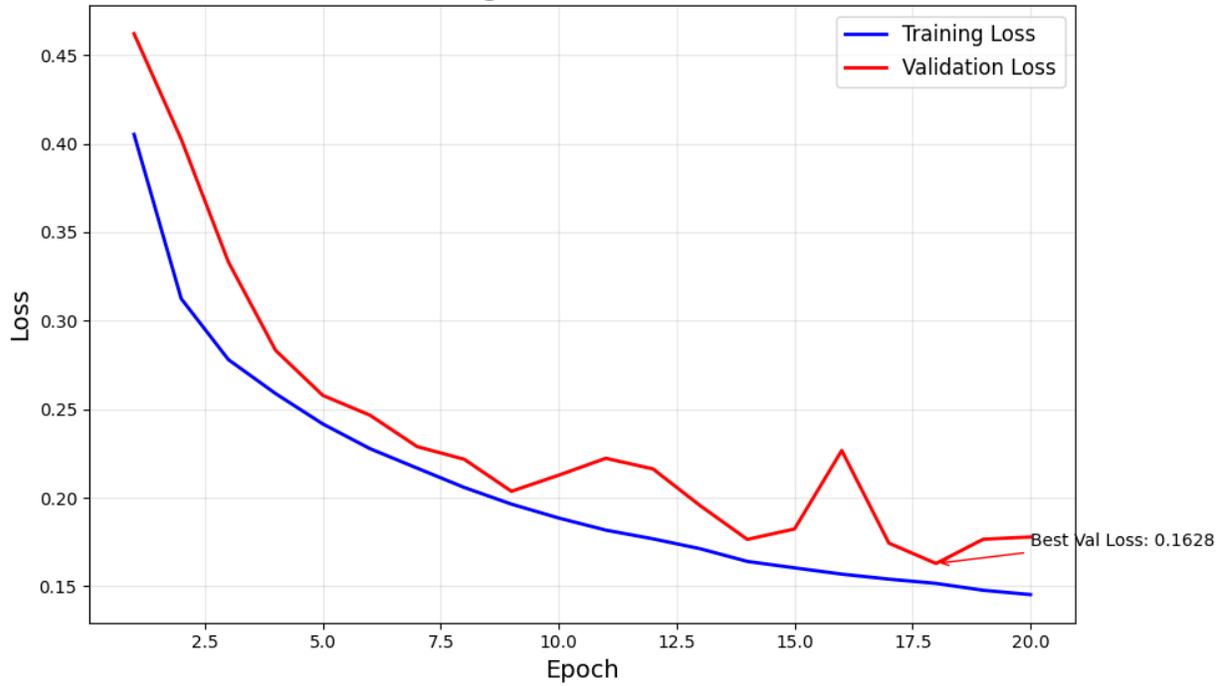
- Simple U-Net
  - Binary segmentation
  - RGB images as input, pixel-level mask as output
  - U-shaped, encoder-decoder, skip connections
- Attention U-Net
  - Enhanced version of U-Net with attention mechanisms
  - Deeper U-shaped network
- Loss Functions
  - BCE Loss (50%) - Doesn't work well for small objects
  - Dice Loss (50%) - Weird probability scores



# Training the models

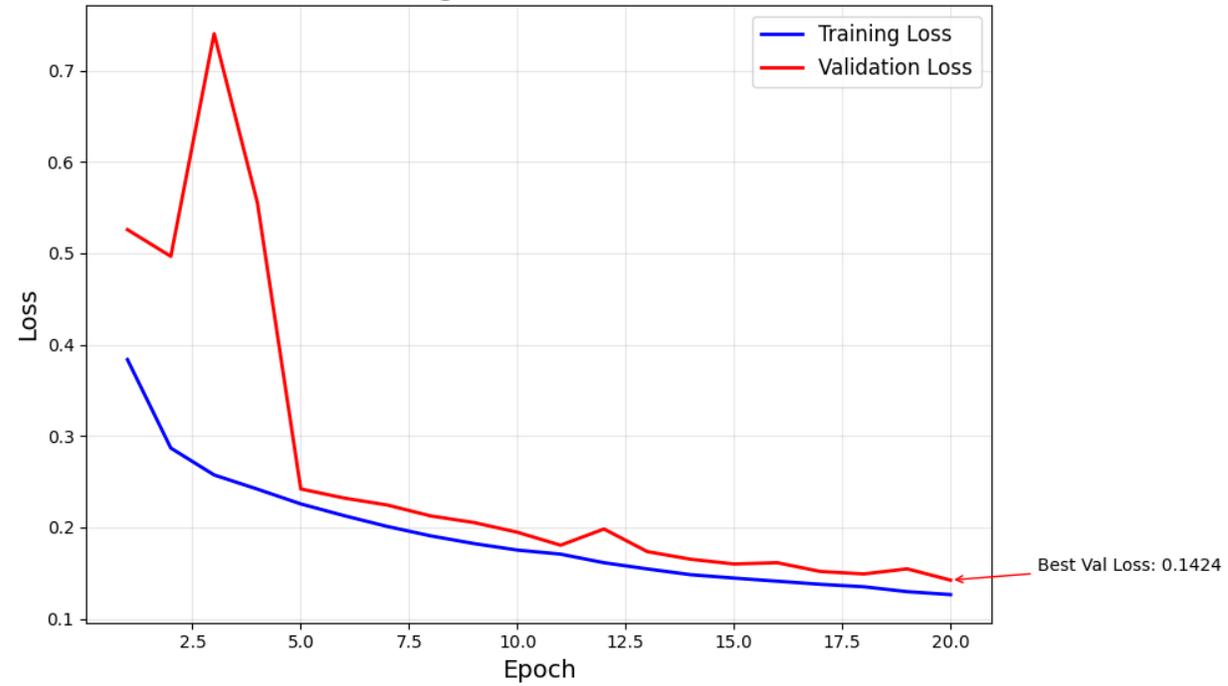
## Simple U-Net

### Training and Validation Loss



## Attention U-Net

### Training and Validation Loss

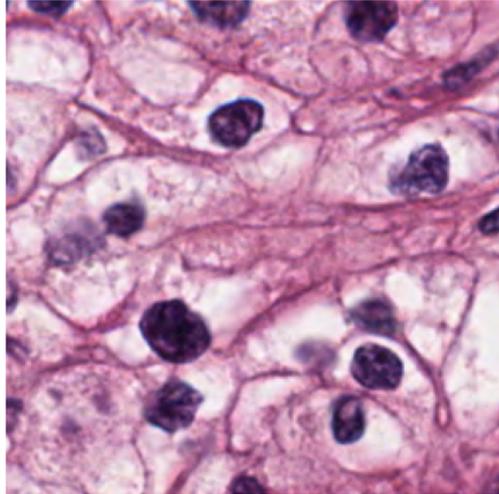


500 images - 20 epochs

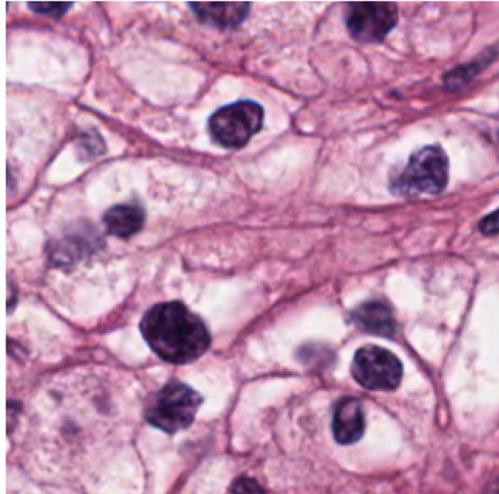
# Models evolution - Epoch 5

Model Comparison - Epoch 5  
Top Row: Probability Maps | Bottom Row: Binary Masks

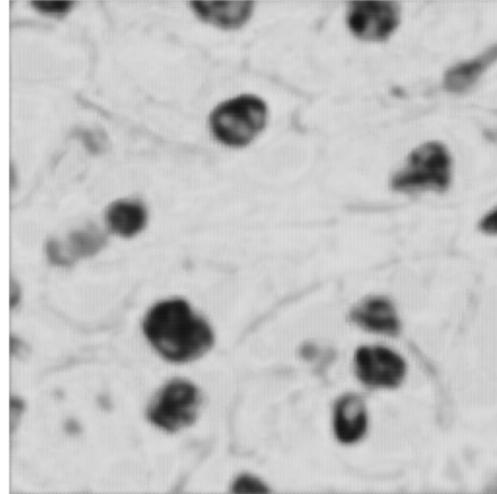
Original Image



Original Image



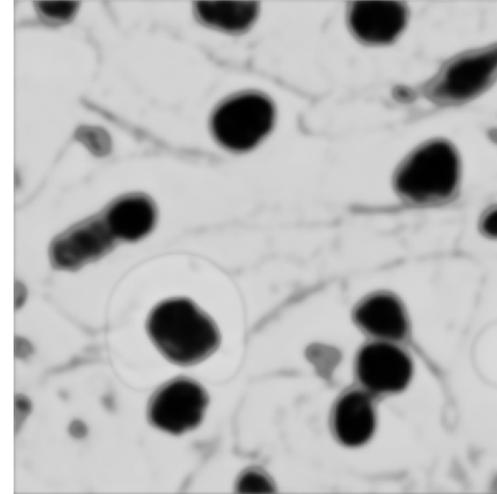
(Probability)



(Binary Mask)



(Probability)



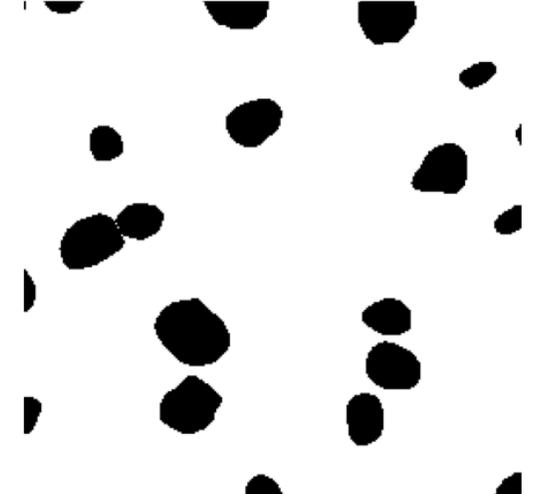
(Binary Mask)



Ground Truth



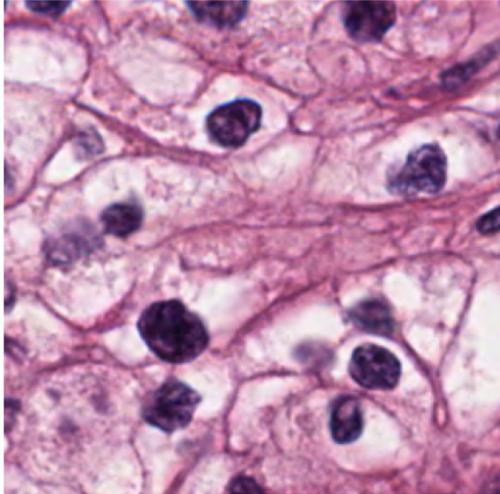
Ground Truth



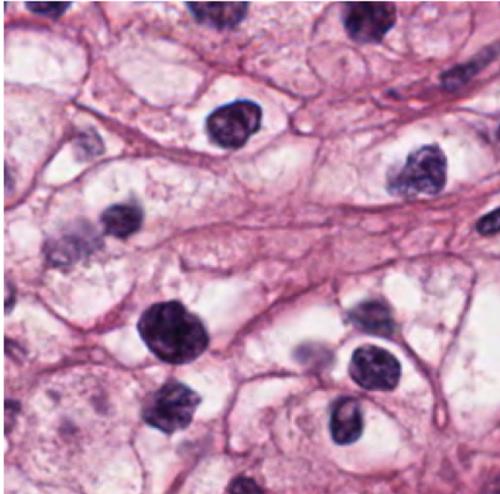
# Models evolution - Epoch 10

Model Comparison - Epoch 10  
Top Row: Probability Maps | Bottom Row: Binary Masks

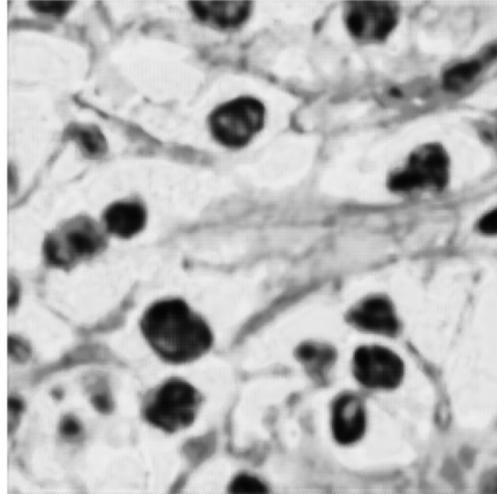
Original Image



Original Image



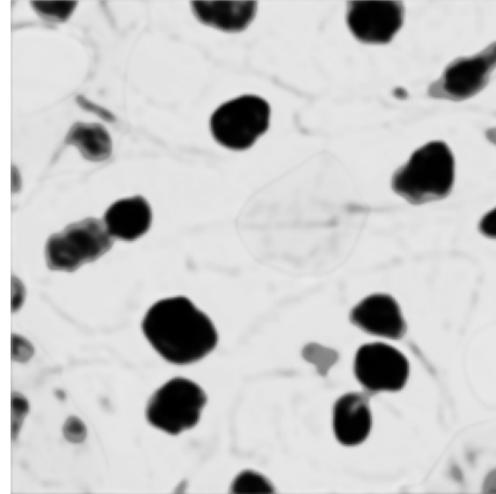
(Probability)



(Binary Mask)



(Probability)



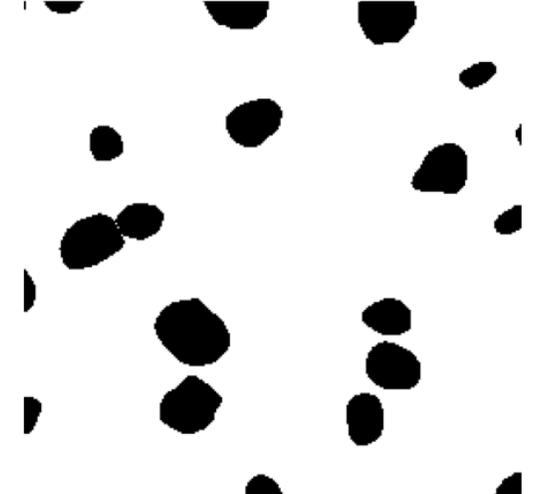
(Binary Mask)



Ground Truth



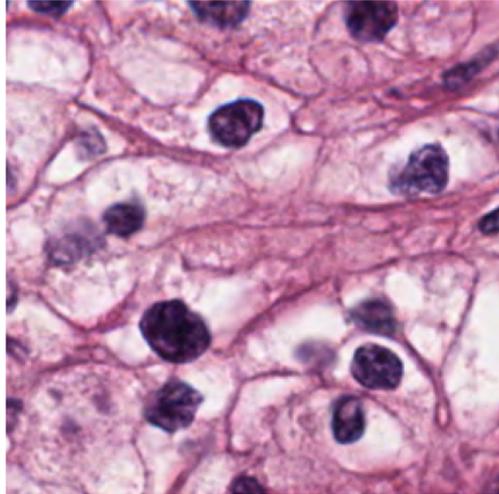
Ground Truth



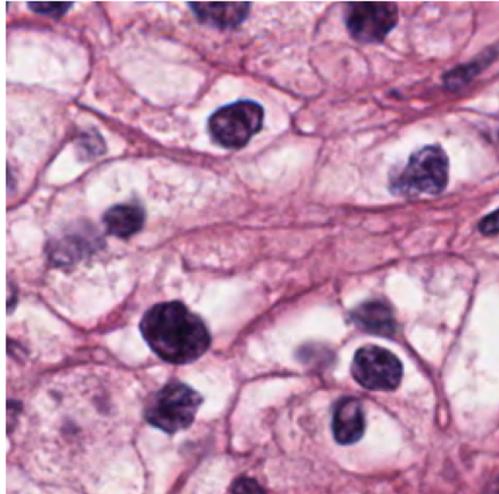
# Models evolution - Epoch 15

Model Comparison - Epoch 15  
Top Row: Probability Maps | Bottom Row: Binary Masks

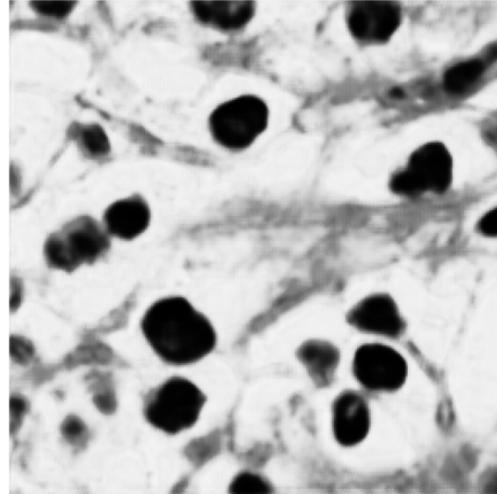
Original Image



Original Image



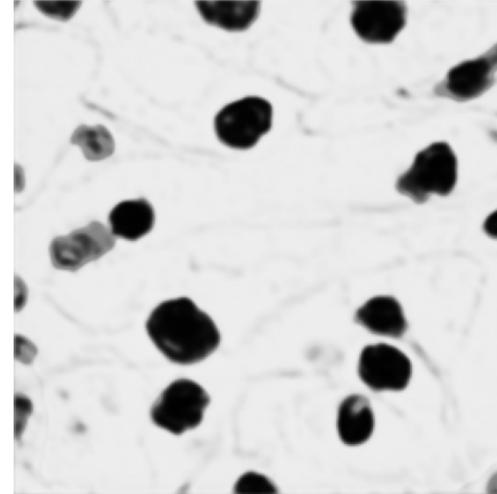
(Probability)



(Binary Mask)



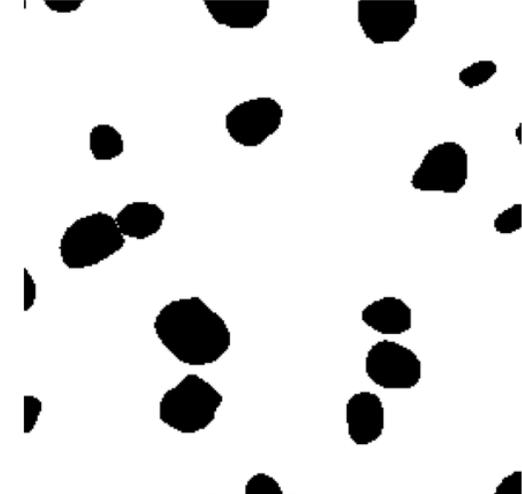
(Probability)



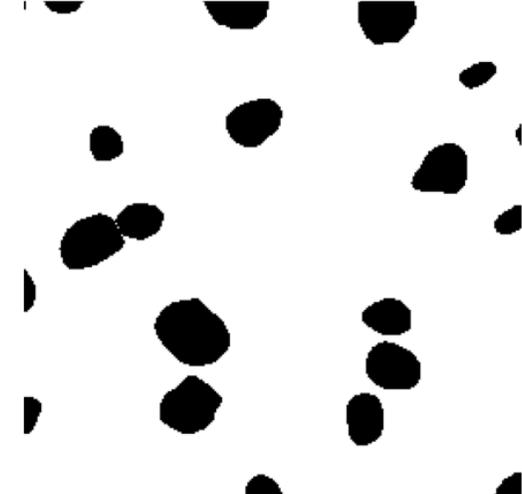
(Binary Mask)



Ground Truth



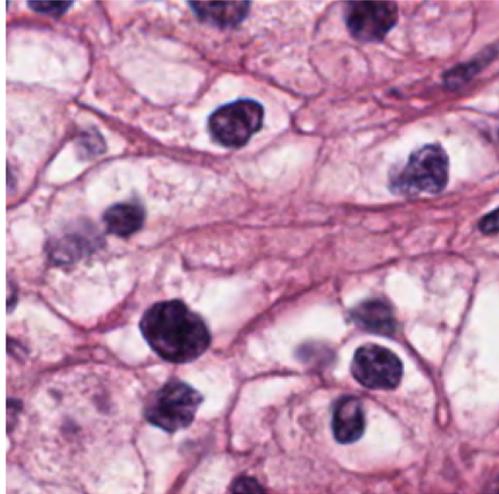
Ground Truth



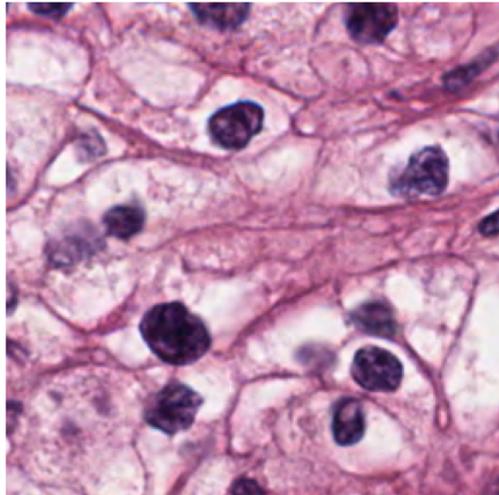
# Models evolution - Epoch 20

Model Comparison - Final Model  
Top Row: Probability Maps | Bottom Row: Binary Masks

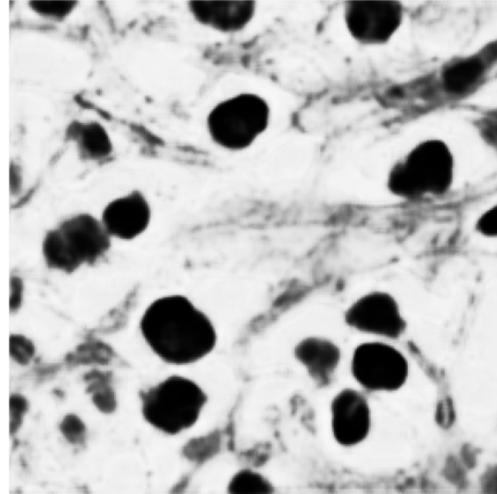
Original Image



Original Image



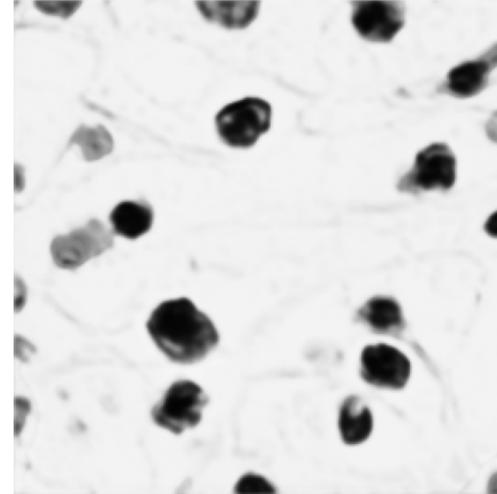
(Probability)



(Binary Mask)



(Probability)



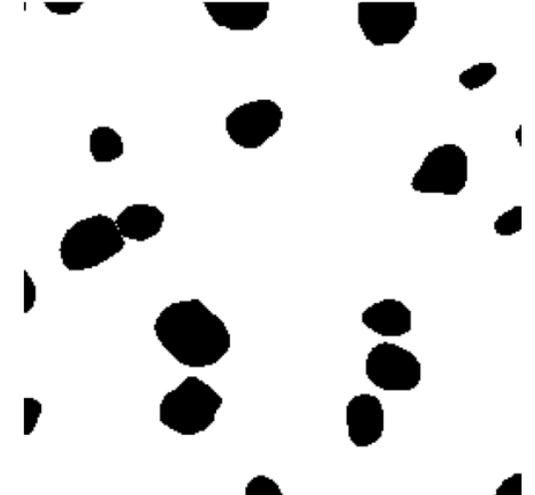
(Binary Mask)



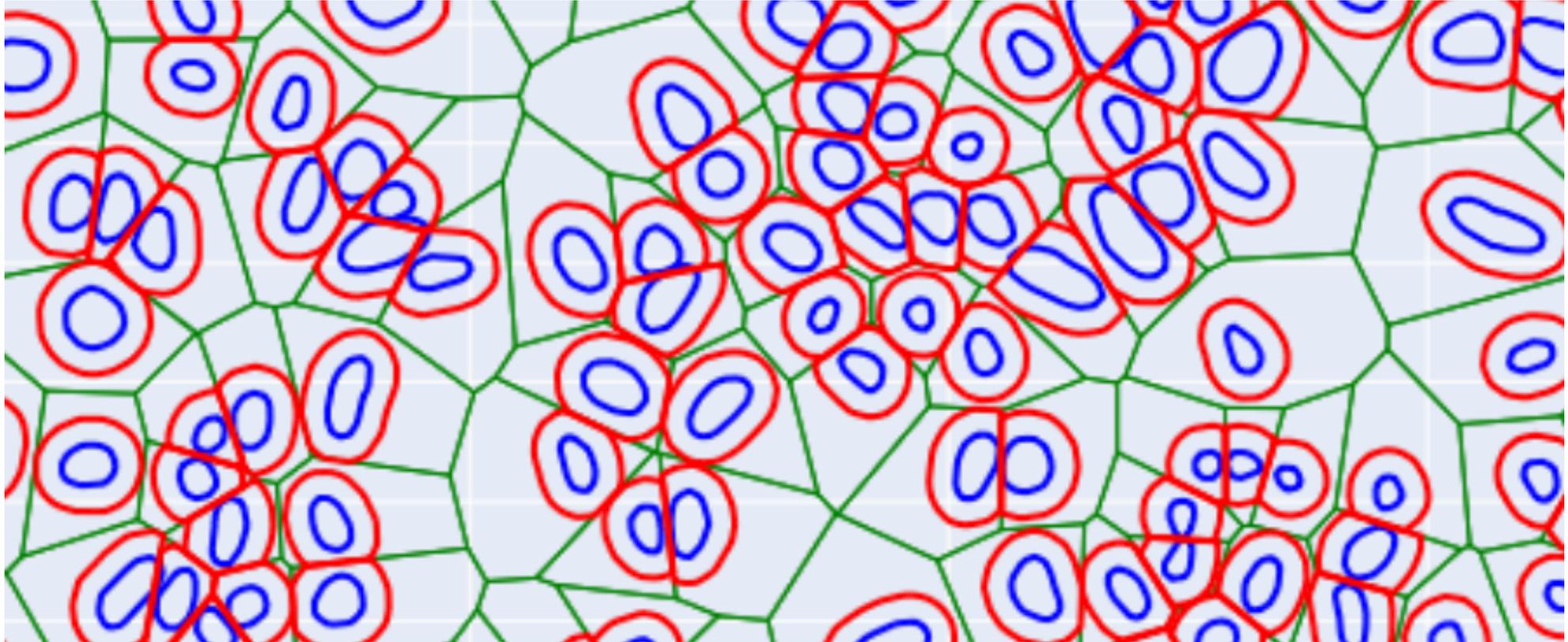
Ground Truth



Ground Truth



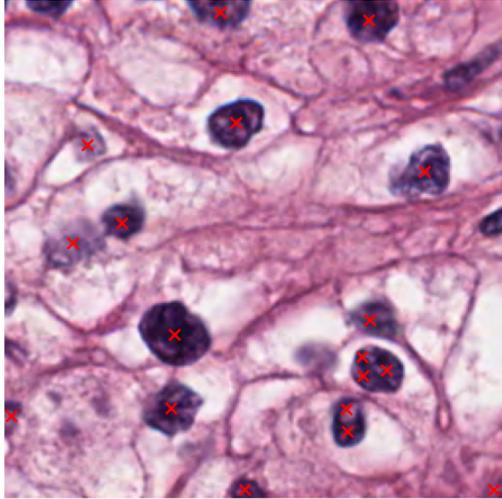
# Nuclei expansion



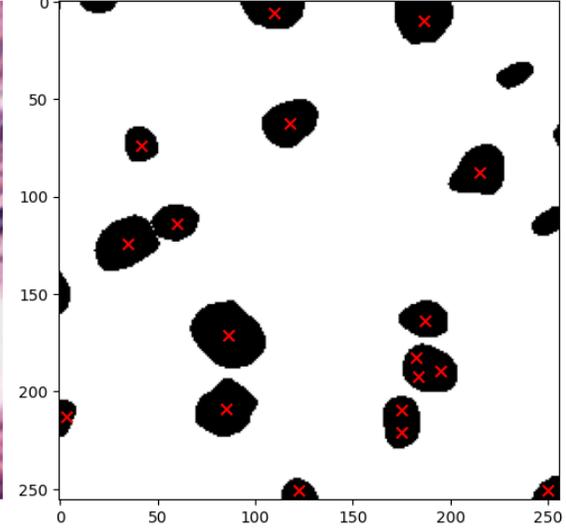
Nuclei expansion to obtain cell boundaries. The original nuclei boundaries (blue) are used to create a Voronoi diagram (green). Each nucleus is expanded within its Voronoi polygon by the user-defined distance to yield non-overlapping cell boundaries (red).

# Voronoi Polygons

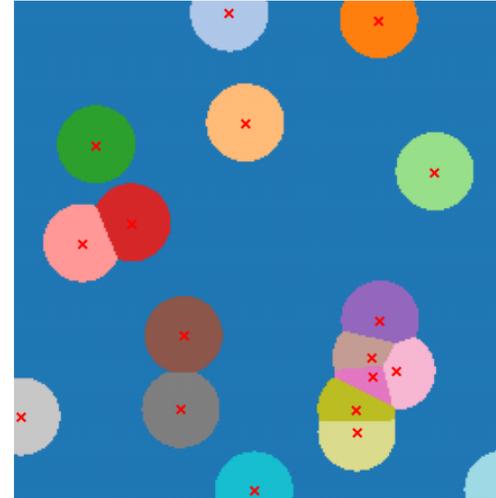
Original + Centroids



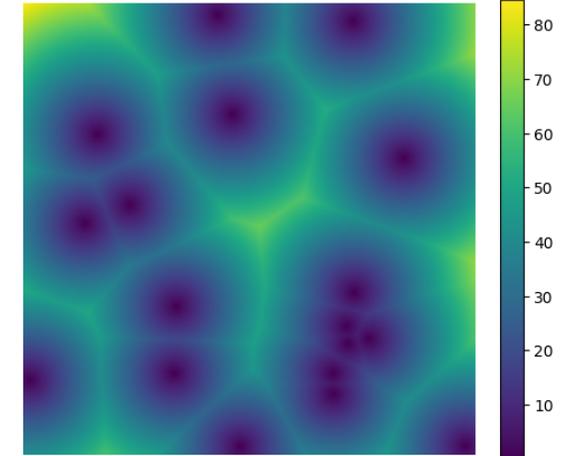
Ground Truth + Detected Centroids



Voronoi Segmentation



Distance to Nearest Nucleus



# Thank you

