Colon Gland Segmentation with Deep Convolutional Neural Networks and Total Variation Segmentation

Team vision4GlaS

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Colon Gland Segmentation Algorithm Overview

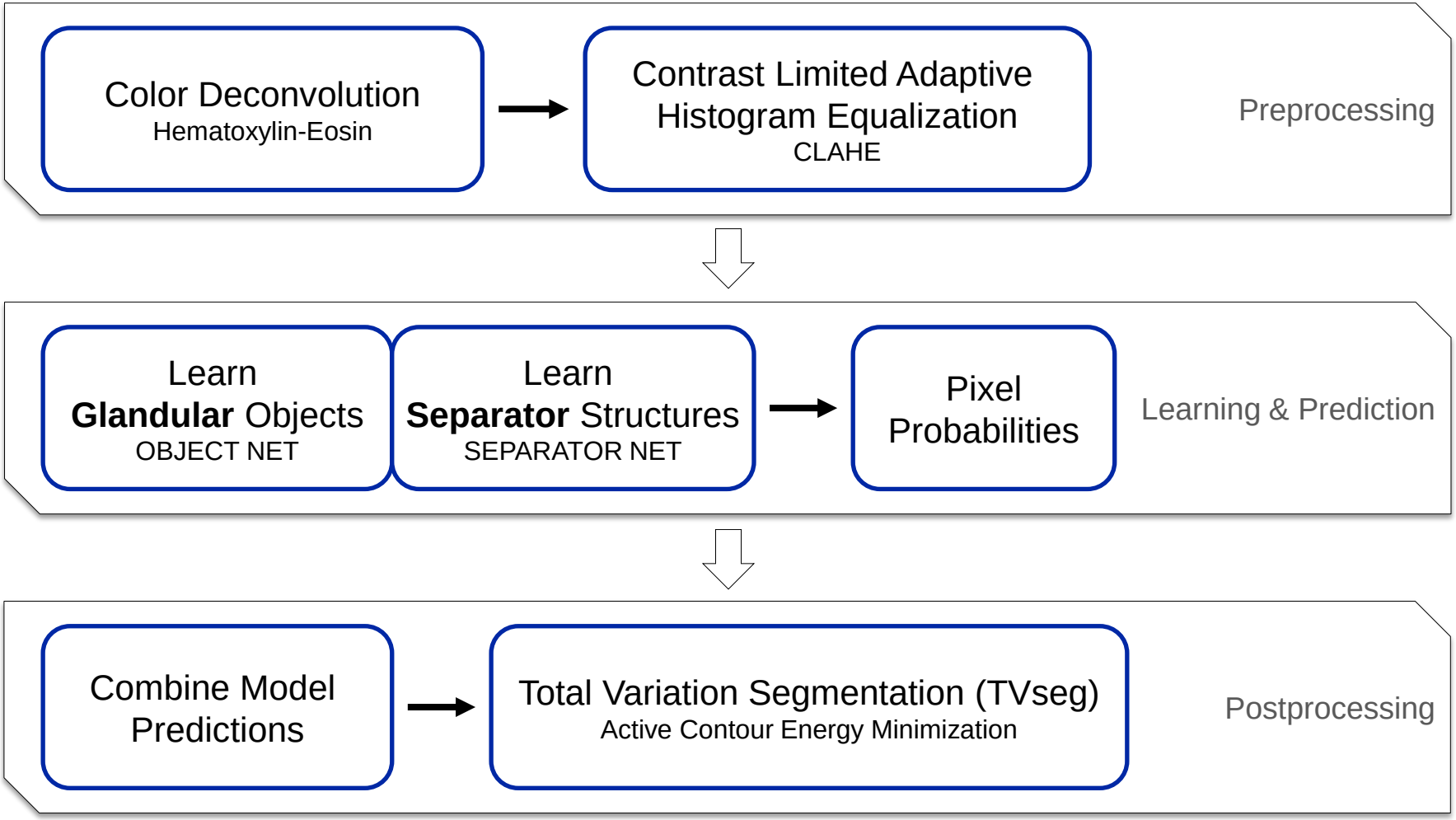
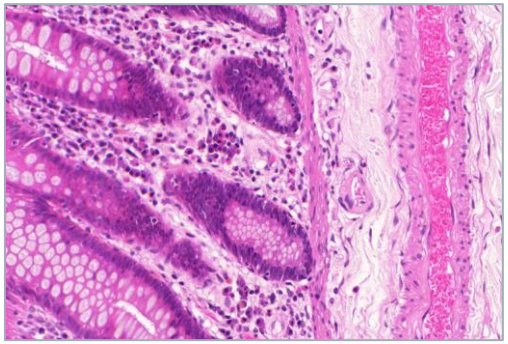
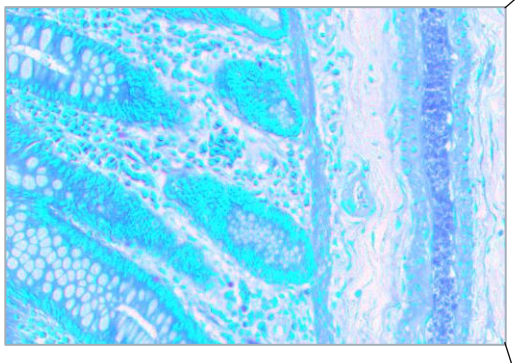


Image Preprocessing: Tissue Decomposition

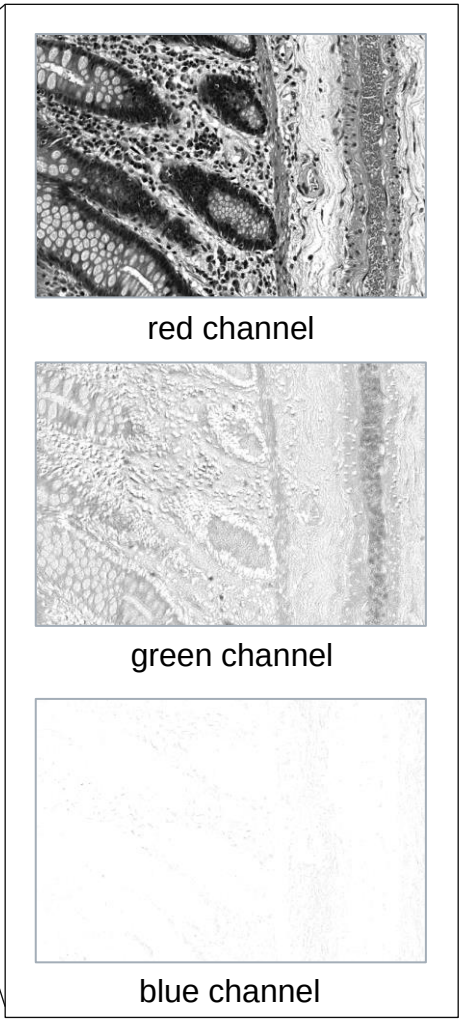
Color Deconvolution [Ruifrok and Johnston, 2001]



source image (RGB)



deconvolved image (RGB)

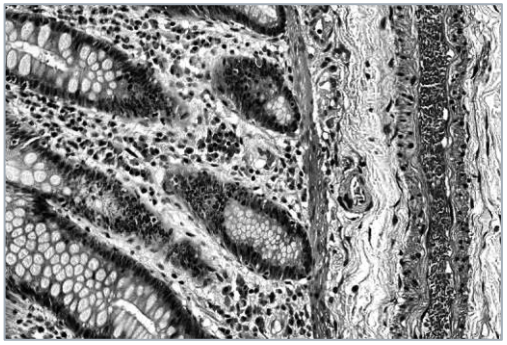


red channel

green channel

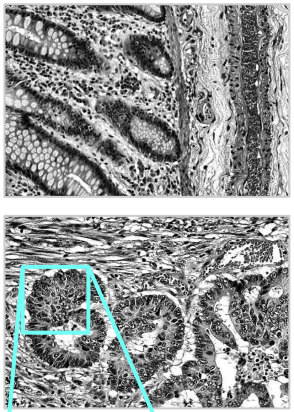
blue channel

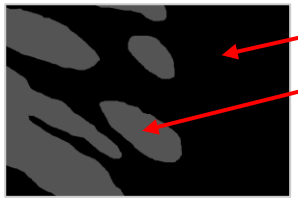
Contrast Limited Adaptive Histogram Equalization [Zuiderveld, 1994]



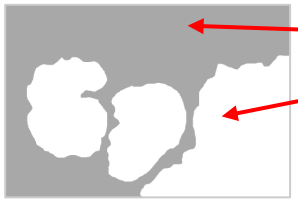
red channel, CLAHE

Learning Glandular Objects





C_0: background benign
C_1: gland benign

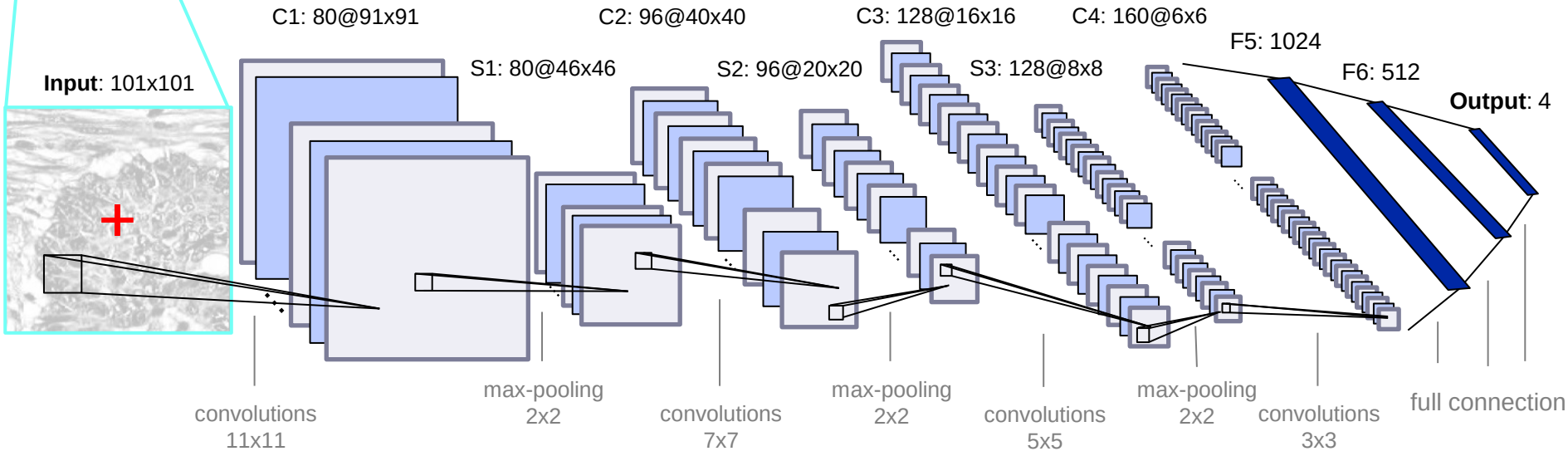


C_2: background malignant
C_3: gland malignant

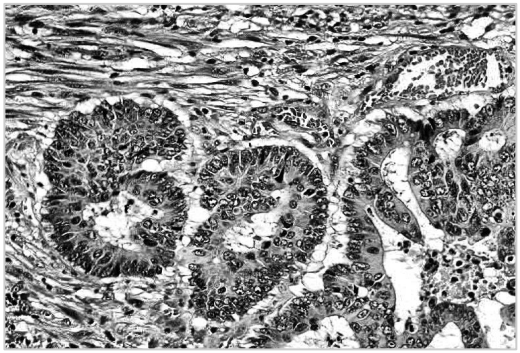
4-Class Classification

OBJECT NET
predicts the label of the center pixel in a 101x101 px patch

Deep Convolutional Neural Network [LeCun *et al.*, 2010]



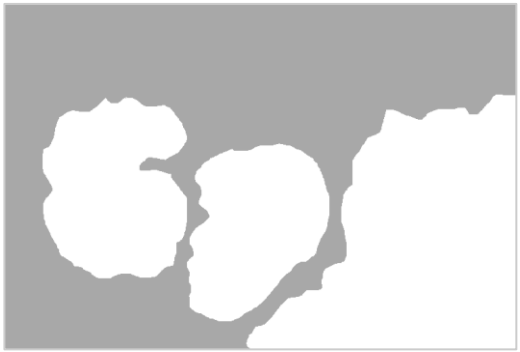
Predicting Glandular Objects



input image

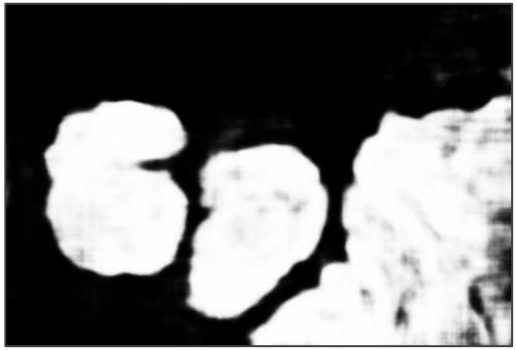
background benign

gland benign



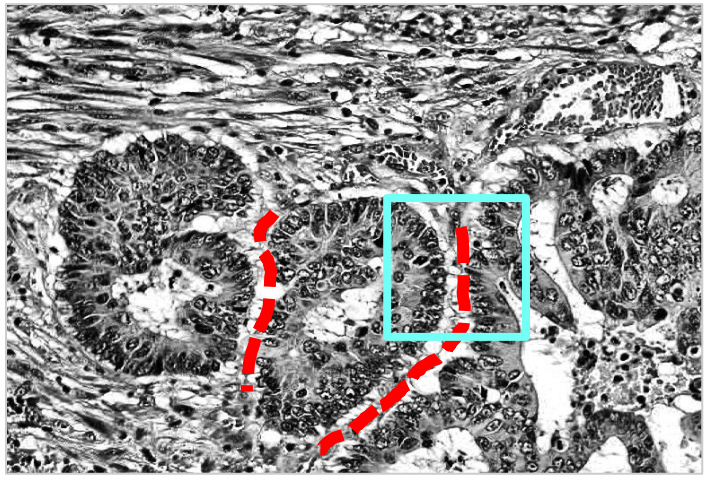
annotation image

background malignant



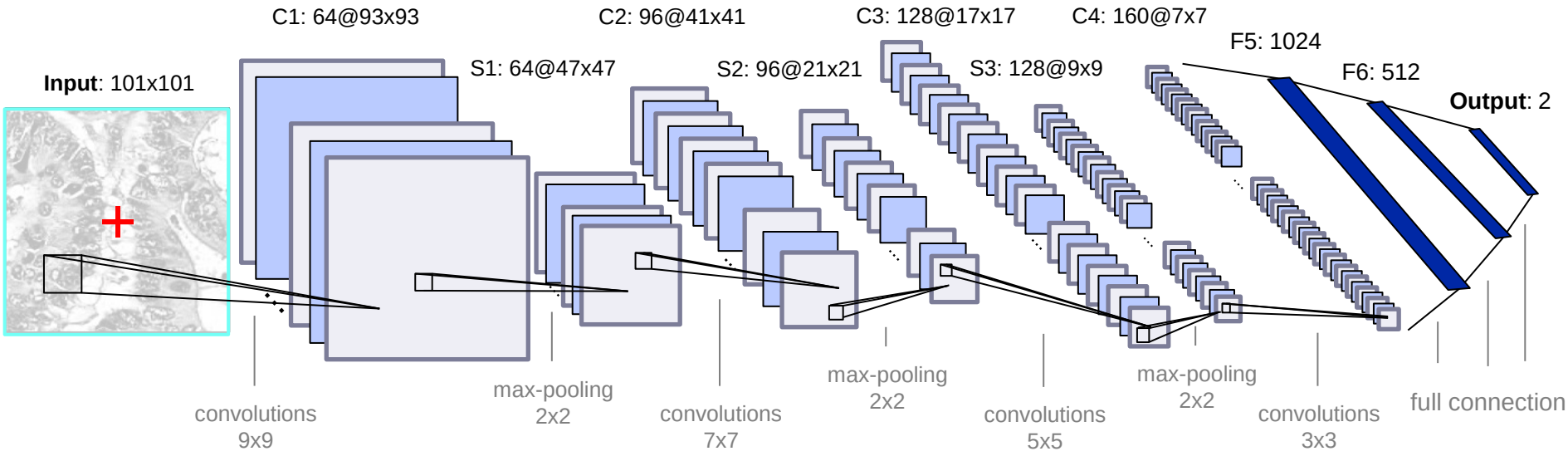
gland malignant

Learning Separator Structures

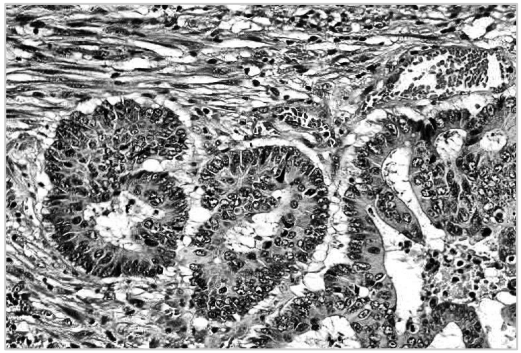


Binary Classification

SEPARATOR NET
predicts the label of the center pixel in a 101x101 px patch

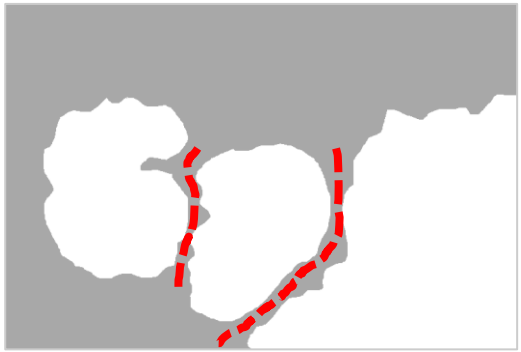


Predicting Separator Structures

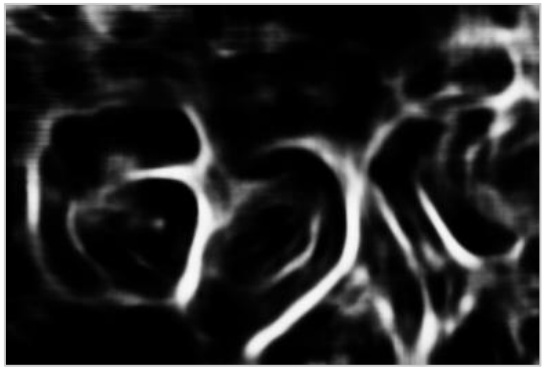


input image

non-separator structures

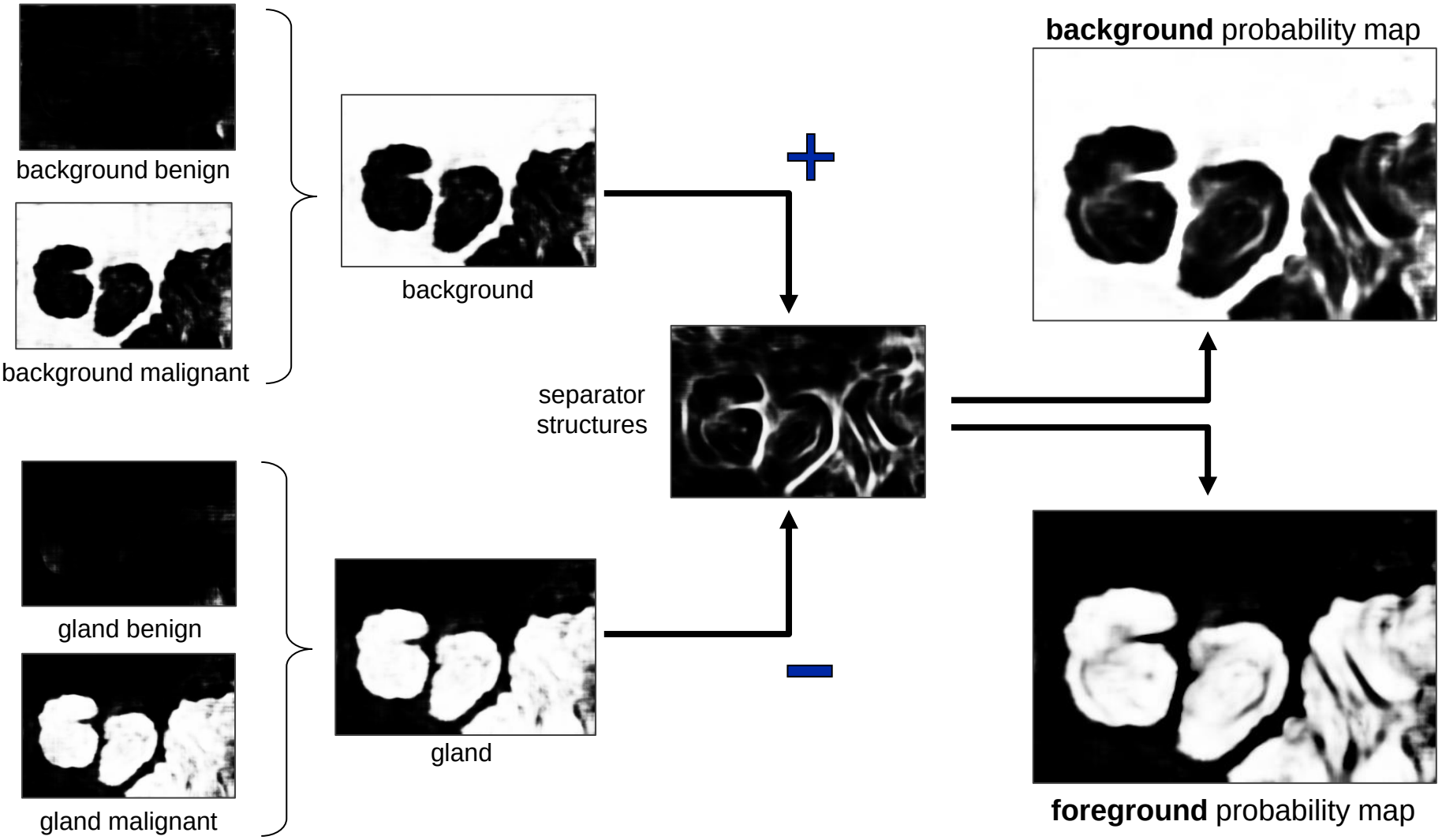


annotation image



separator structures

Combining Model Predictions

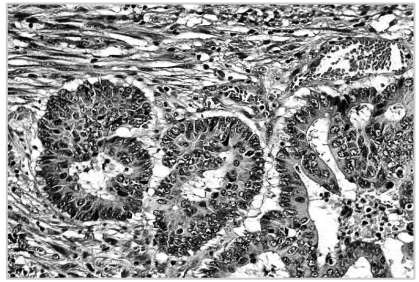


Total Variation Segmentation

Based on a convex geodesic active contour model, a figure-ground segmentation u is computed:

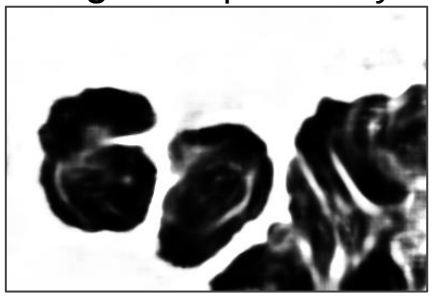
$$\min_u E_{seg}(u) = \min_u \int_\Omega g(x)|\nabla u(x)|\,\mathrm{d}x + \lambda \int_\Omega u(x) \cdot w(x)\,\mathrm{d}x$$

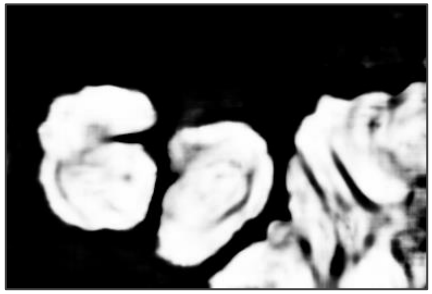
$$\text{s.t.} \qquad u \in C_{box} = \{u : u(x) \in [0,1], \forall\, x \in \Omega\}$$



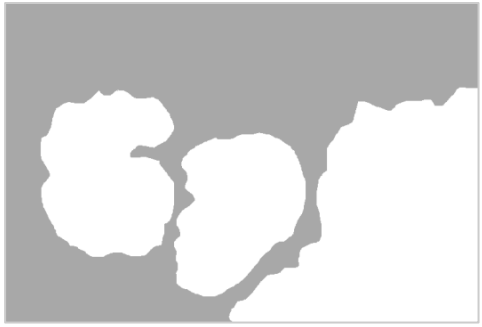
input I(x)

background probability map

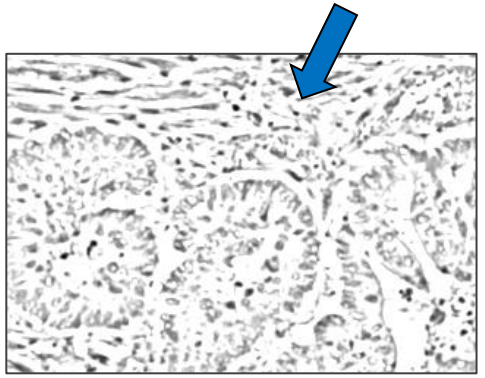




foreground probability map



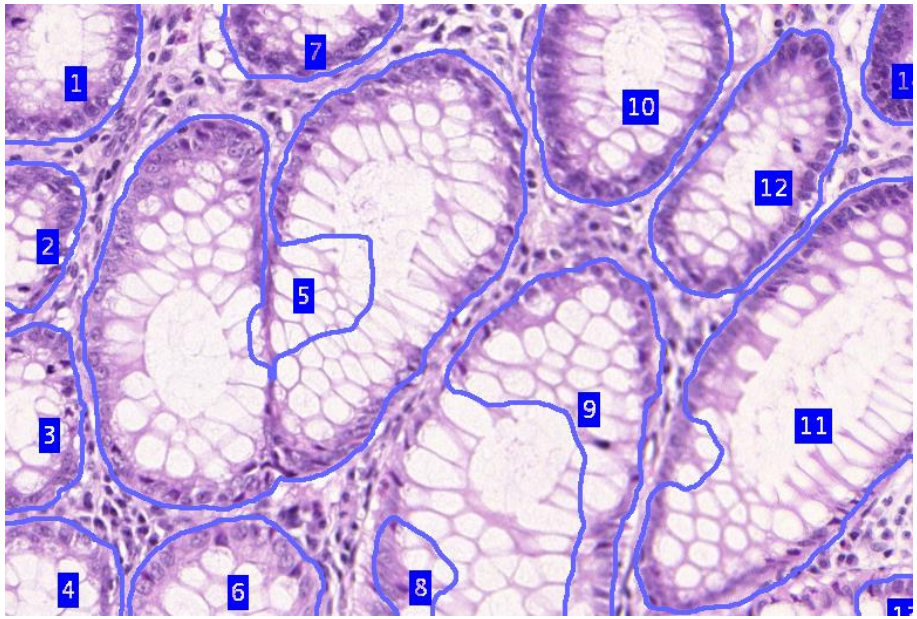
segmentation u

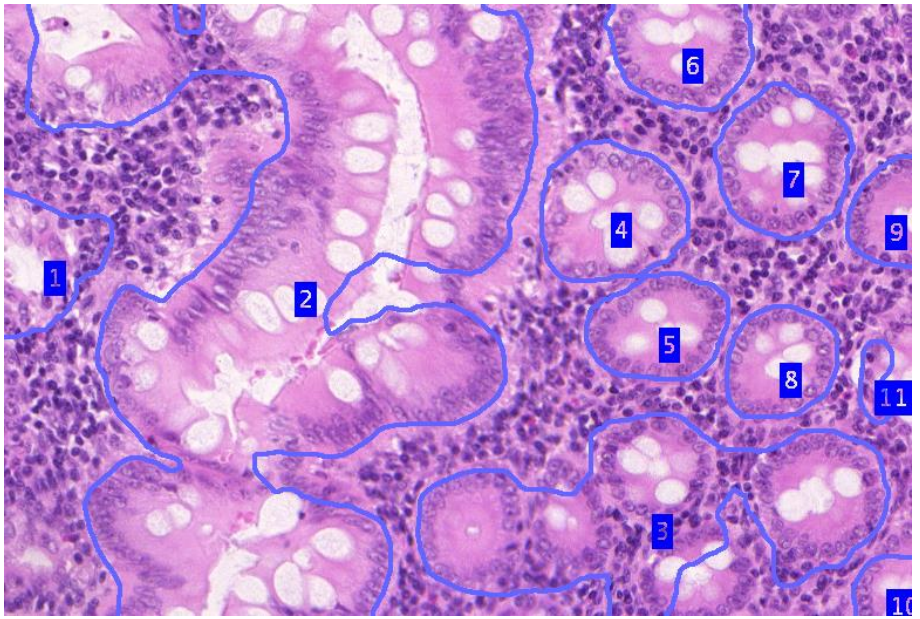


$$g(x) = e^{-\alpha\|\nabla I(x)\|^\beta},\ \alpha, \beta > 0$$

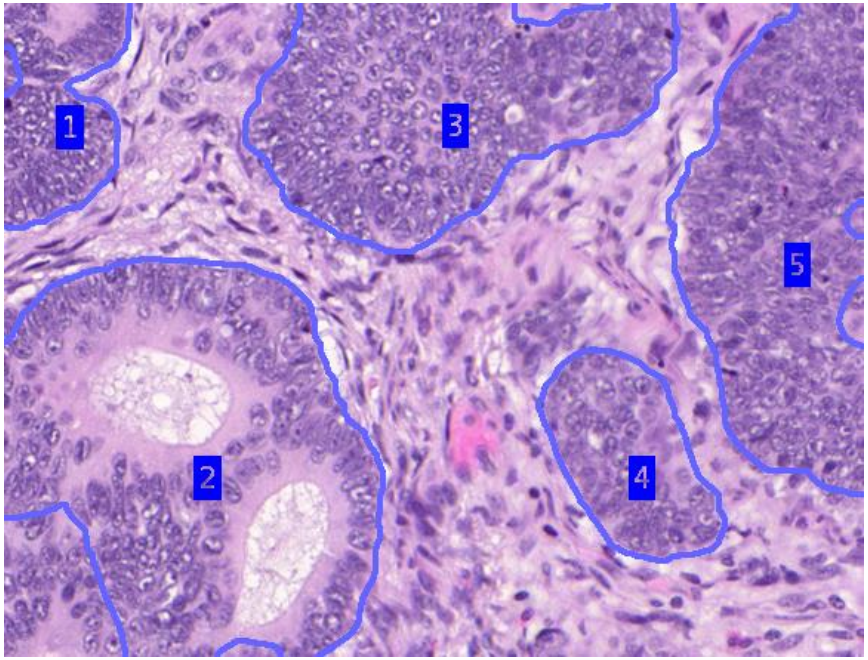
Globally optimal solution giving minimal contour length

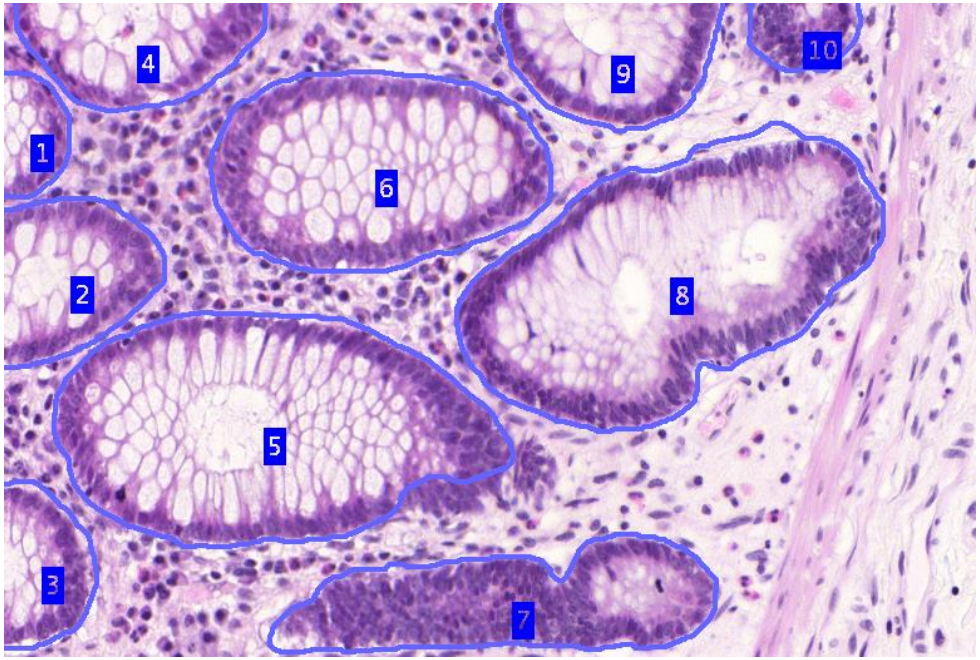
Segmentation Results: Test Set A (off-site)

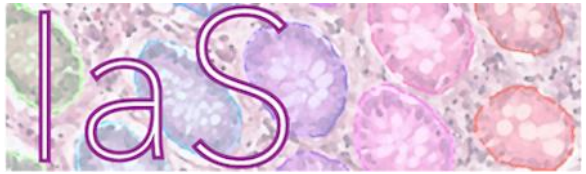




Segmentation Results: Test Set A (off-site)







Thanks for your attention!

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