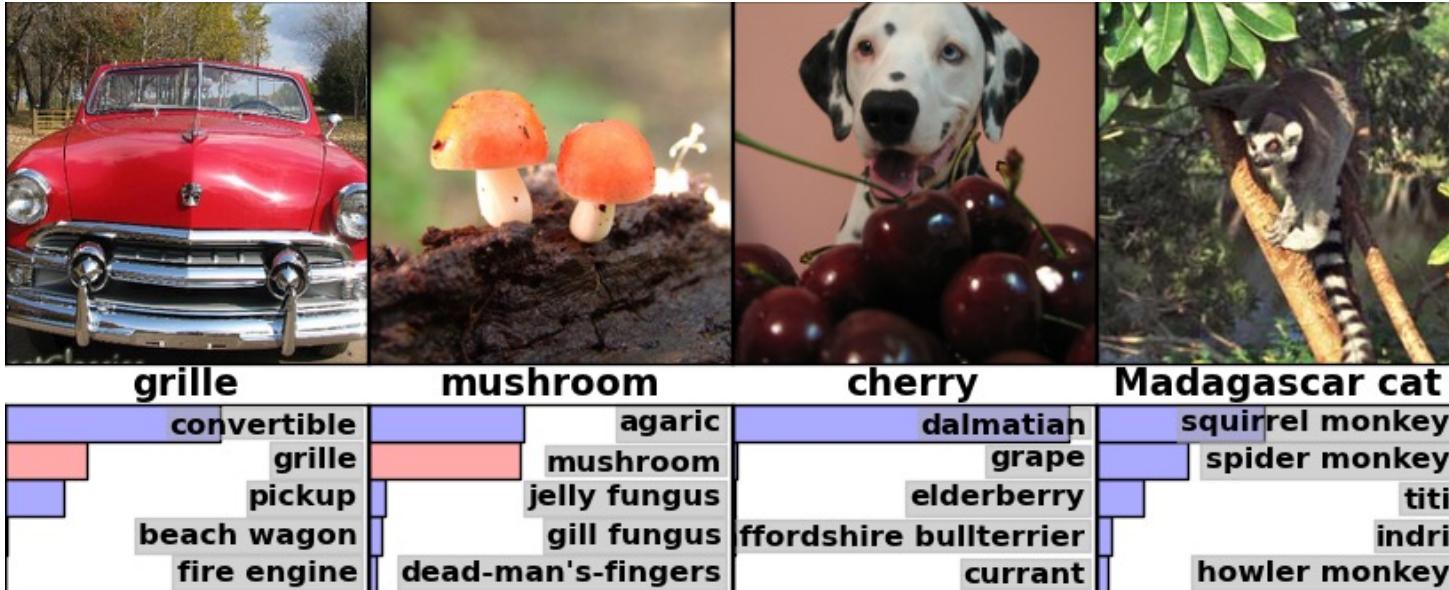


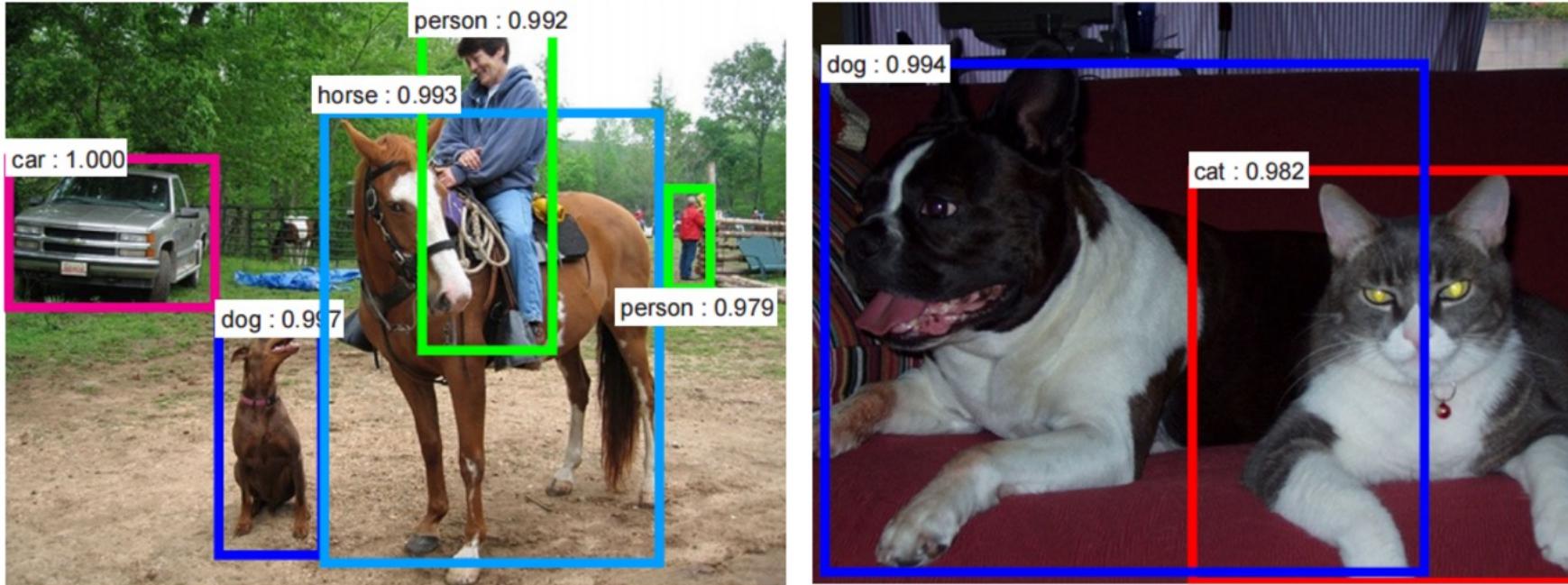
# Medical Image Analysis: Beyond Classification

Matthew Engelhard

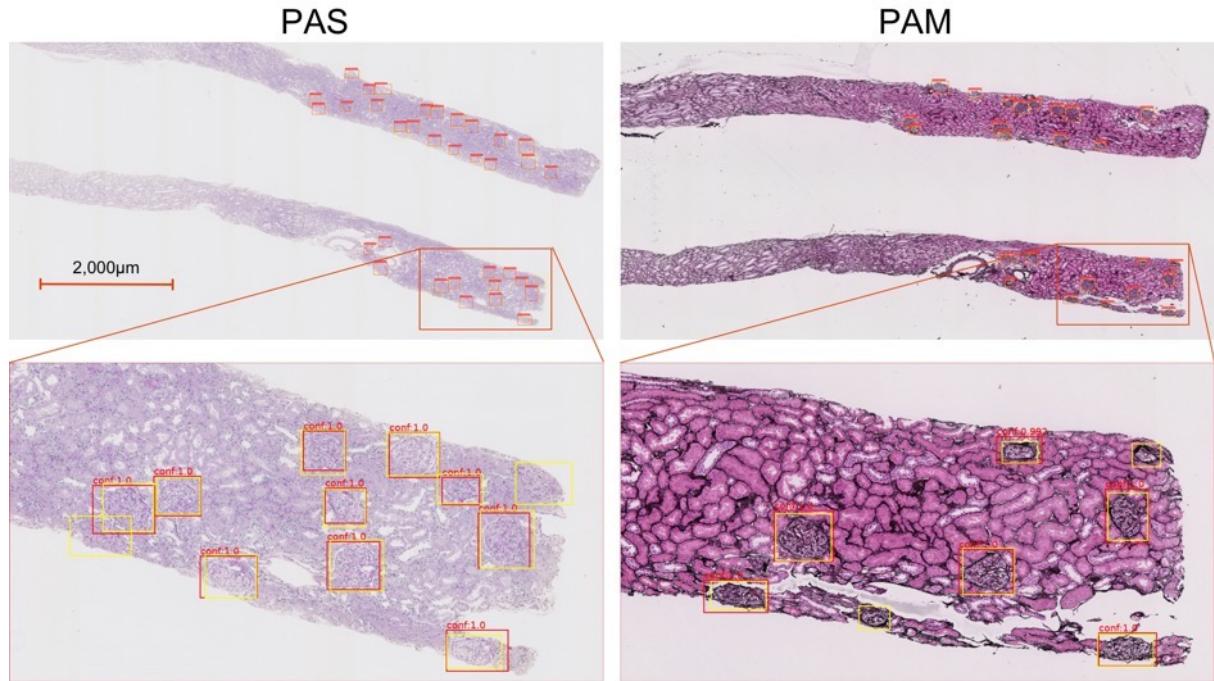
# Which label is best?



# Detection: propose regions and predict their labels

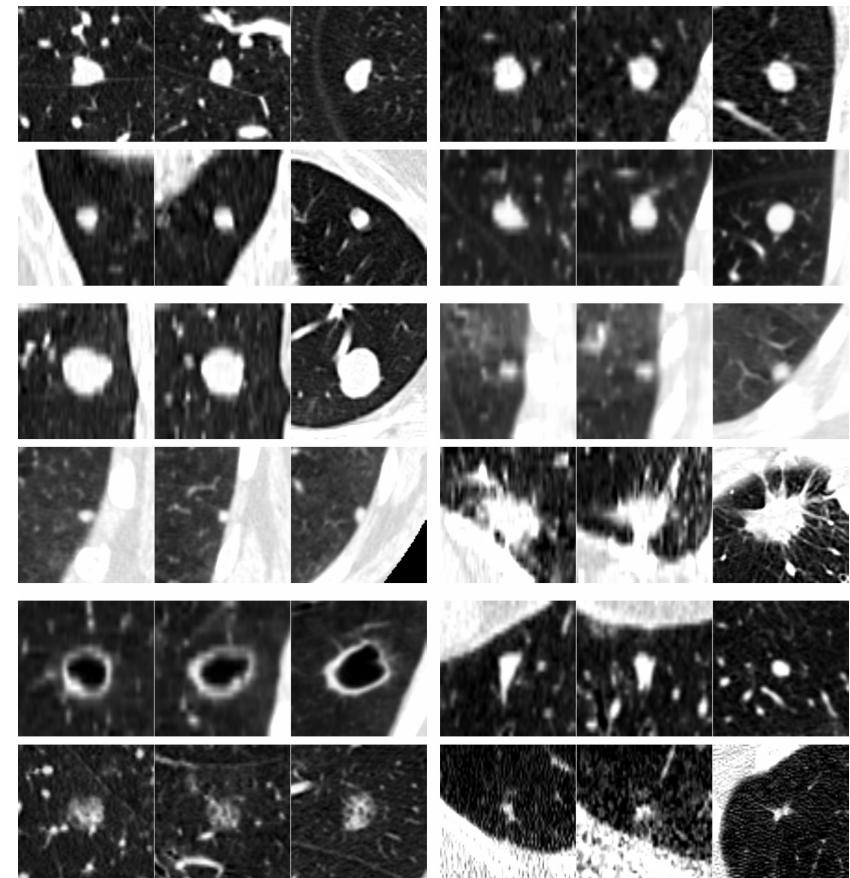


# Detection in medicine



Glomerular Detection with Faster-RCNN

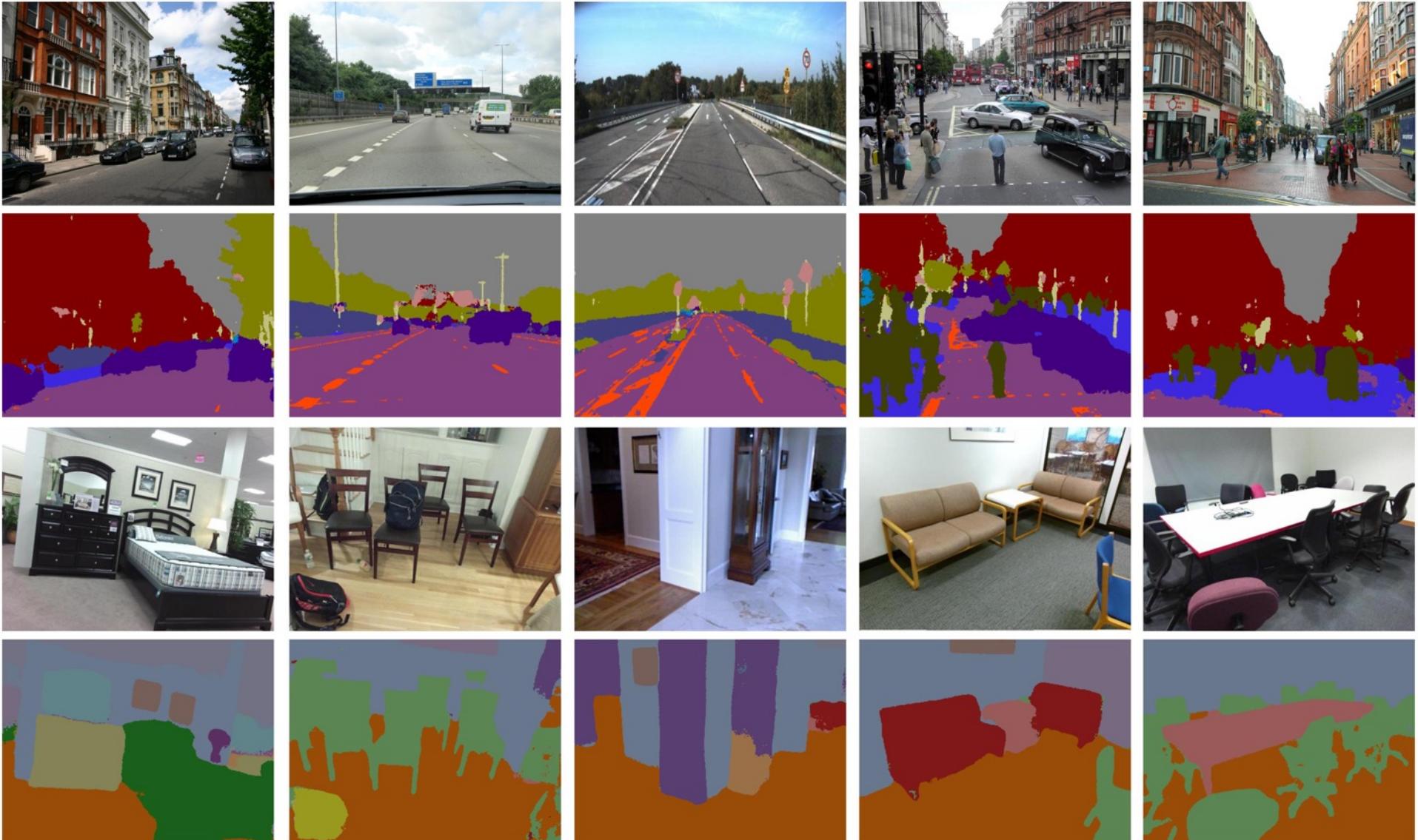
Kawazoe et al., *J. Imaging*, 2018



Pulmonary Nodule detection in CT

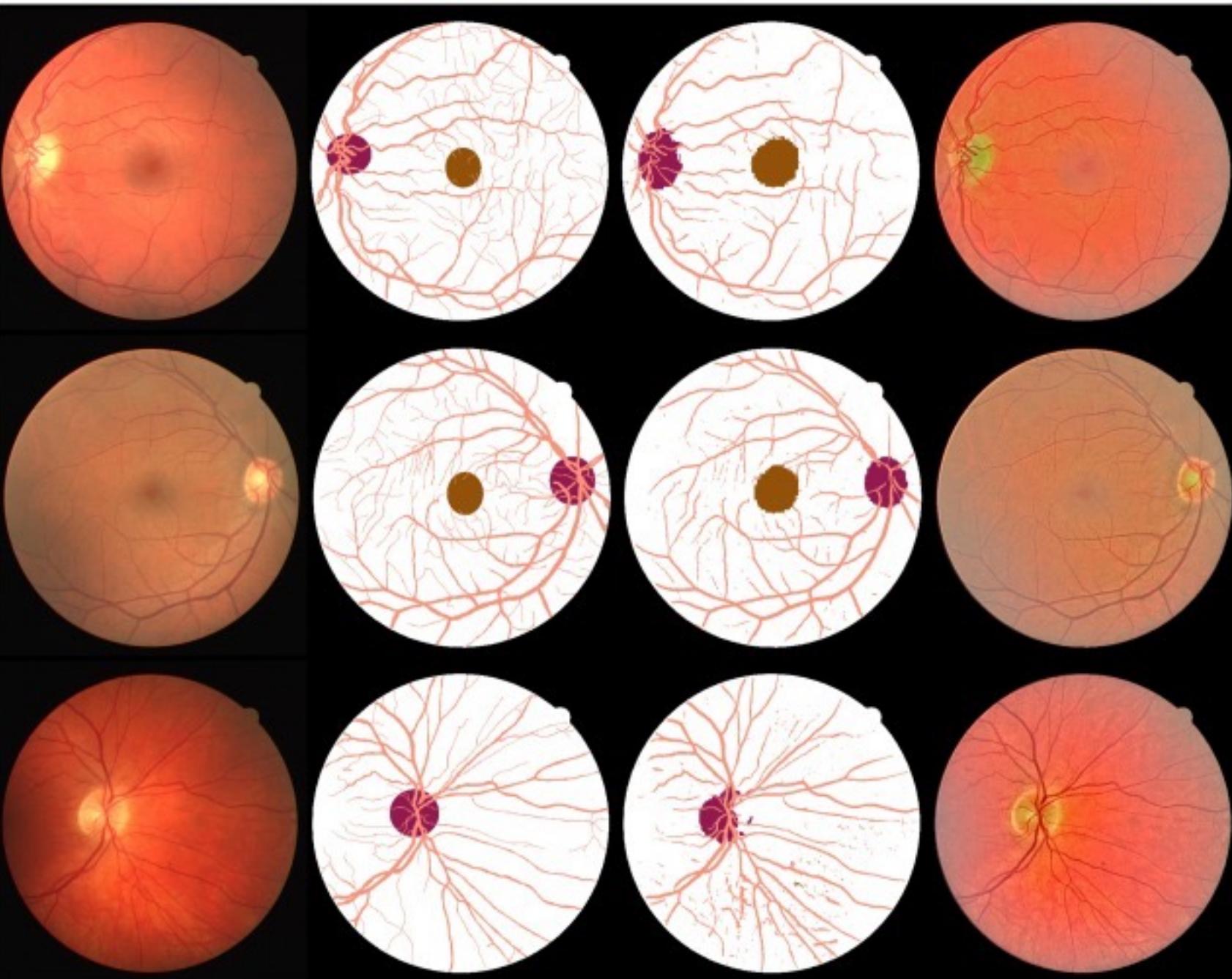
van Ginneken et al., *Biomedical Imaging*, 2015

# Segmentation: predict the label for each pixel

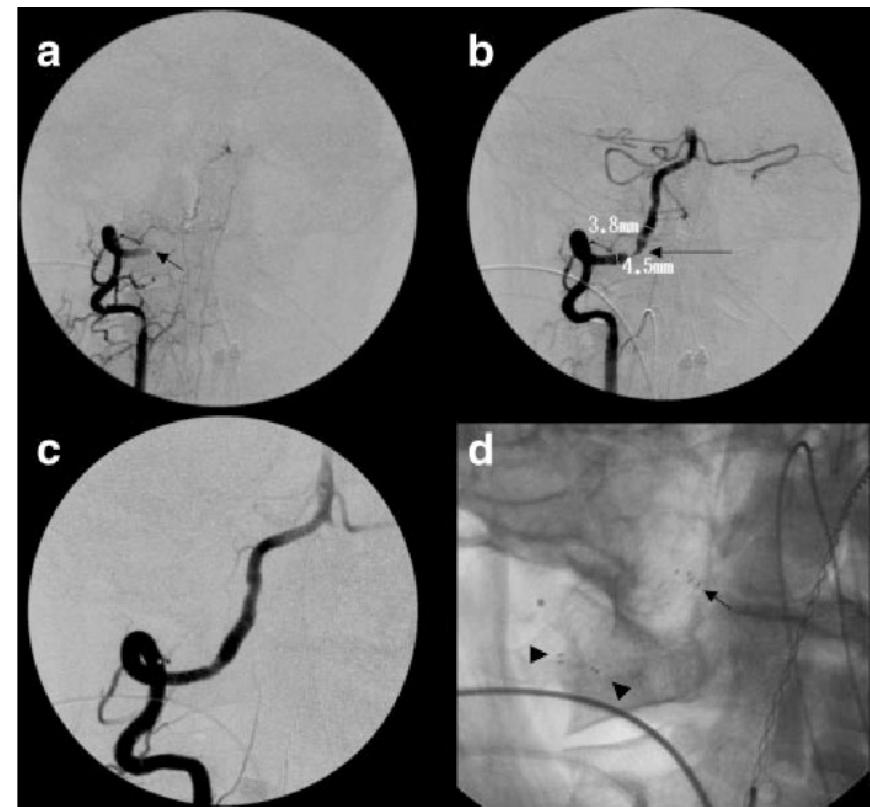


## Segmentation of optic disc, fovea and retinal vasculature

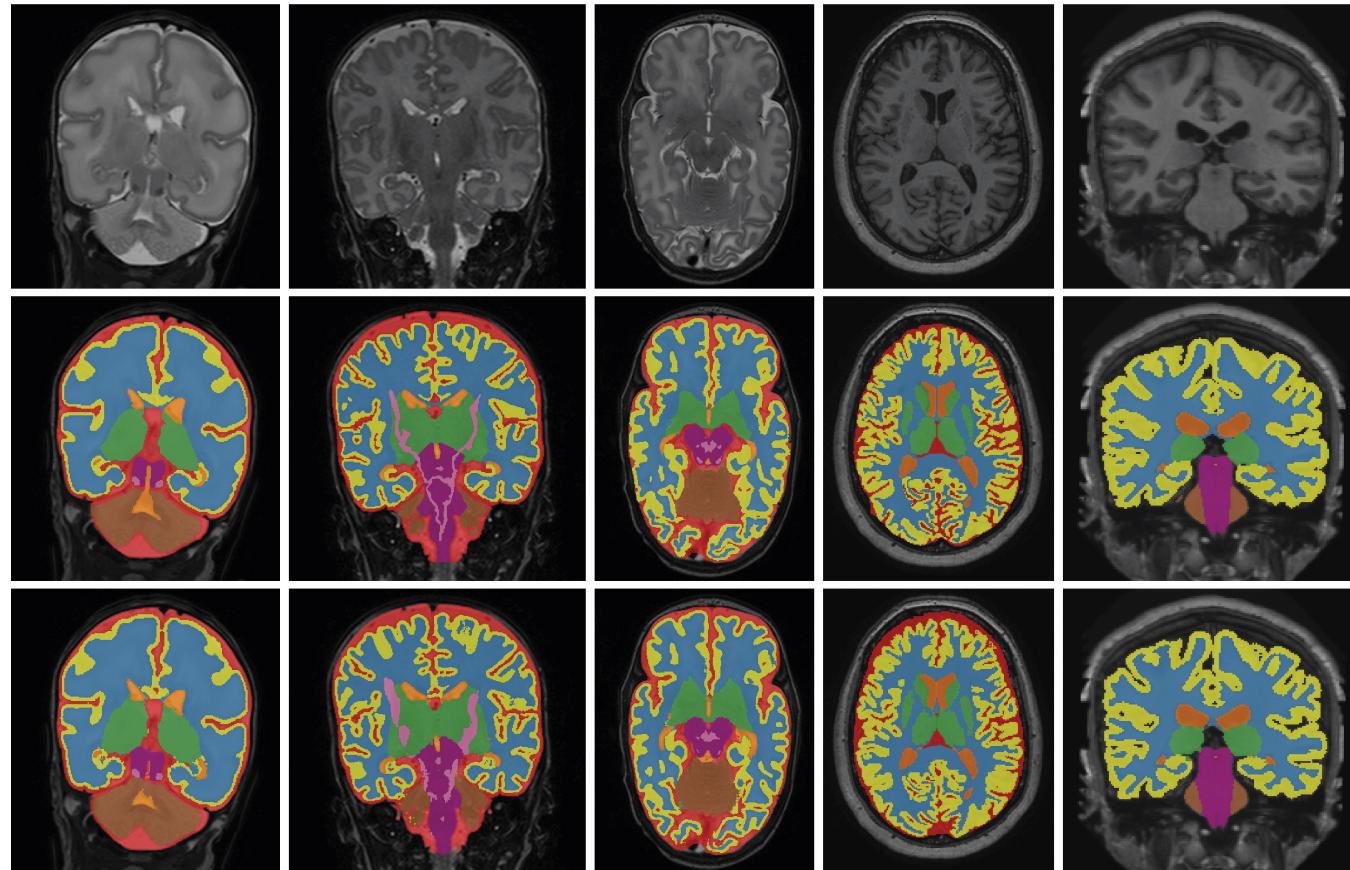
*Journal of Computational  
Science, 20, 70-79 (2017).*



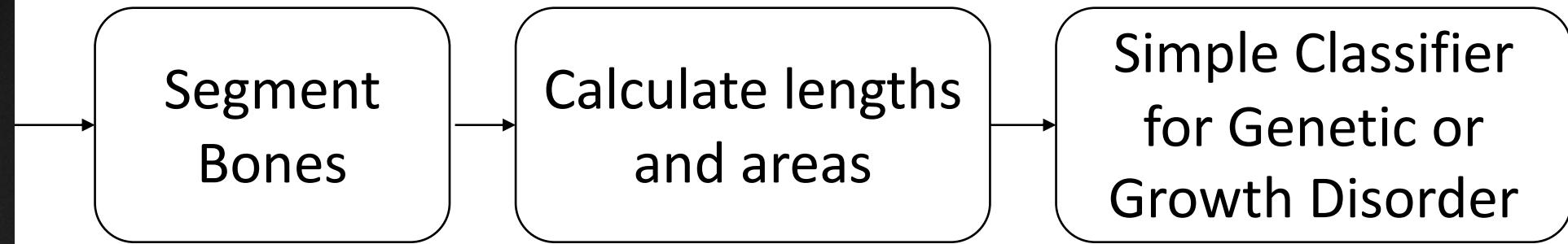
Precisely Identify  
Boundaries



# Determine Areas or Volumes



# Segmentation-based features when end-to-end classification is not feasible



Article | Published: 10 October 2018

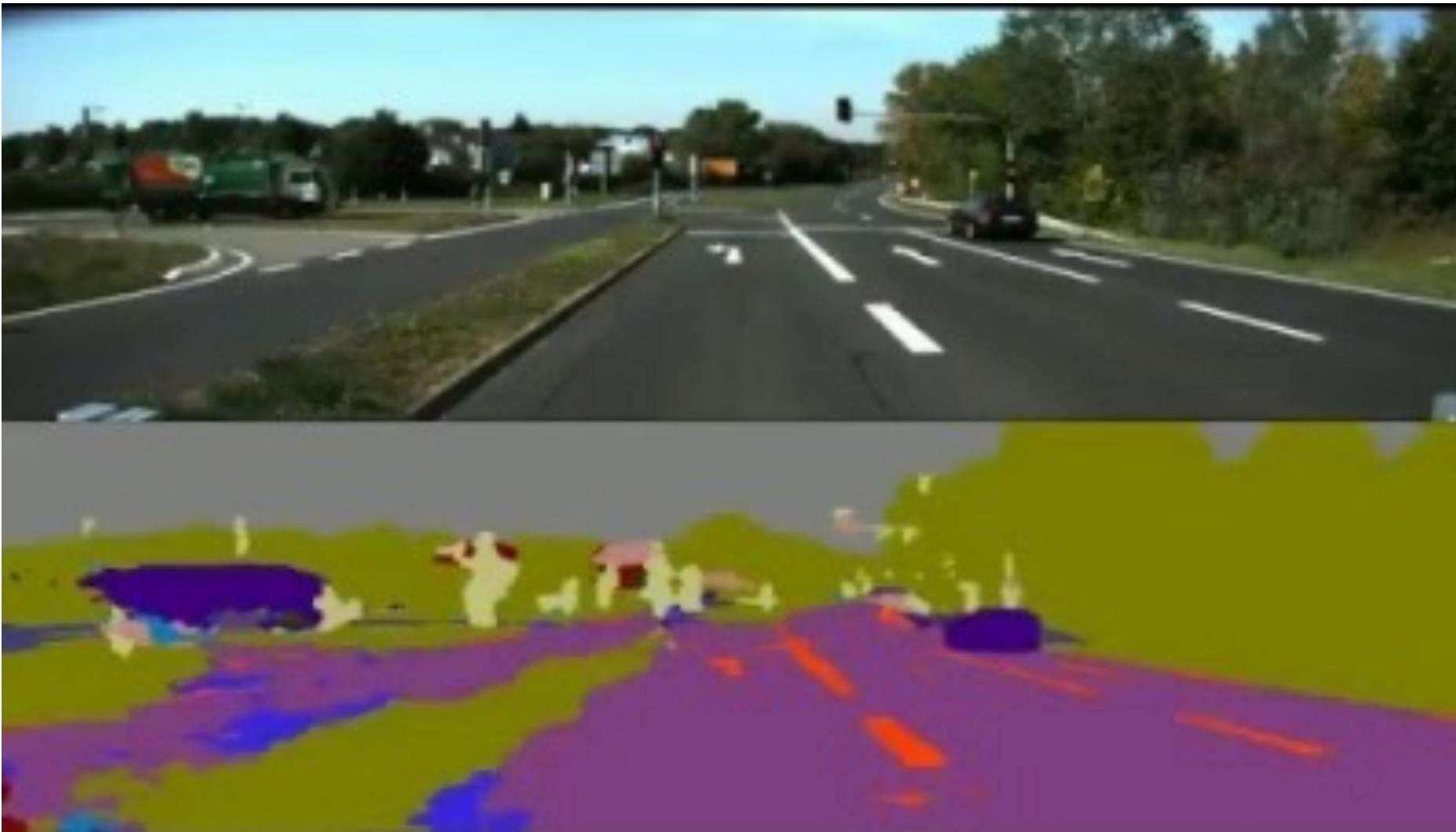
# Development and validation of a deep-learning algorithm for the detection of polyps during colonoscopy

Pu Wang, Xiao Xiao, Jeremy R. Glissen Brown, Tyler M. Berzin, Mengtian Tu, Fei Xiong, Xiao Hu, Peixi Liu, Yan Song, Di Zhang, Xue Yang, Liangping Li, Jiong He, Xin Yi, Jingjia Liu & Xiaogang Liu ✉

*Nature Biomedical Engineering* **2**, 741–748 (2018) | Download Citation ↓

# Colon Polyp Segmentation

# Approach: Start with SegNet (2015)



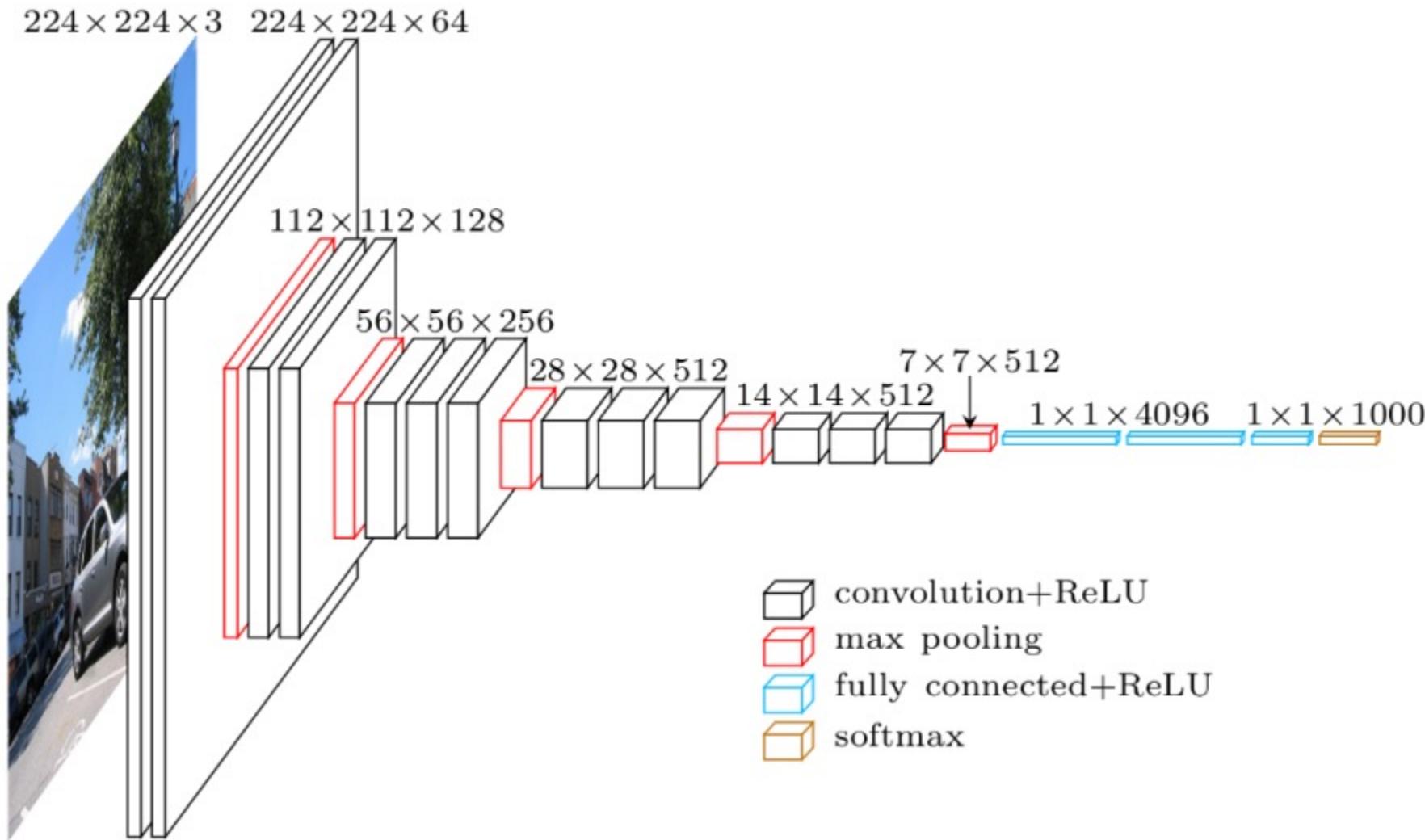
Retrain to segment  
polyps in real time



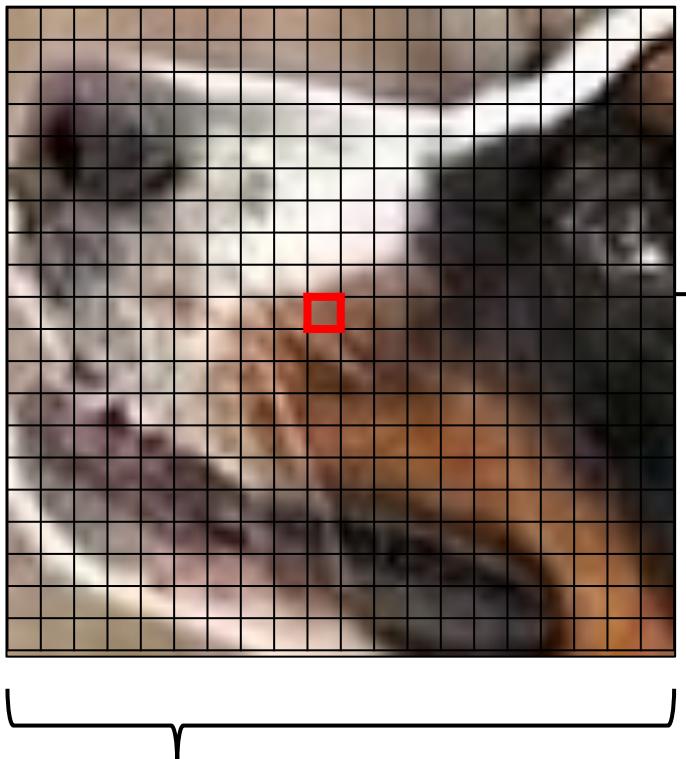
# Segmentation in Brief

(Additional Material)

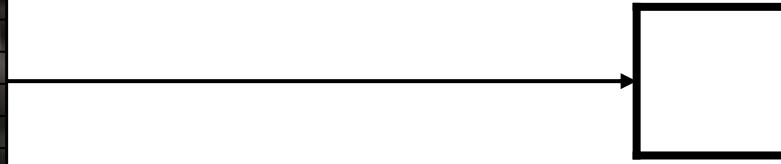
# Classification Architecture (VGG)



# A separate classifier for each pixel?



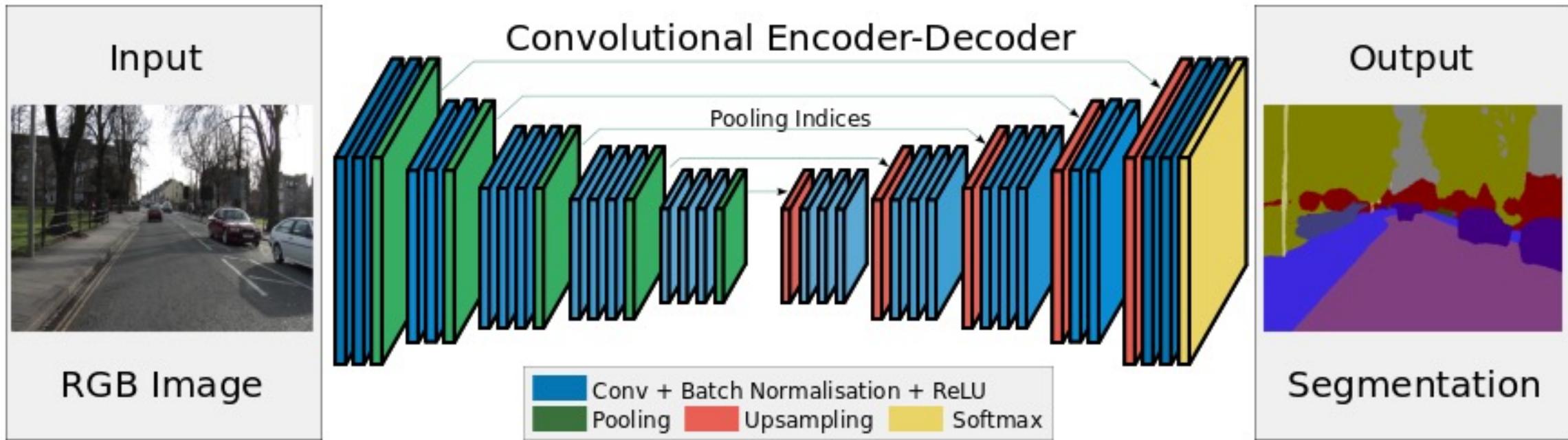
$x$ , data/features



$y$ , associated  
value or label

End goal: predict  $y$  from  $x$

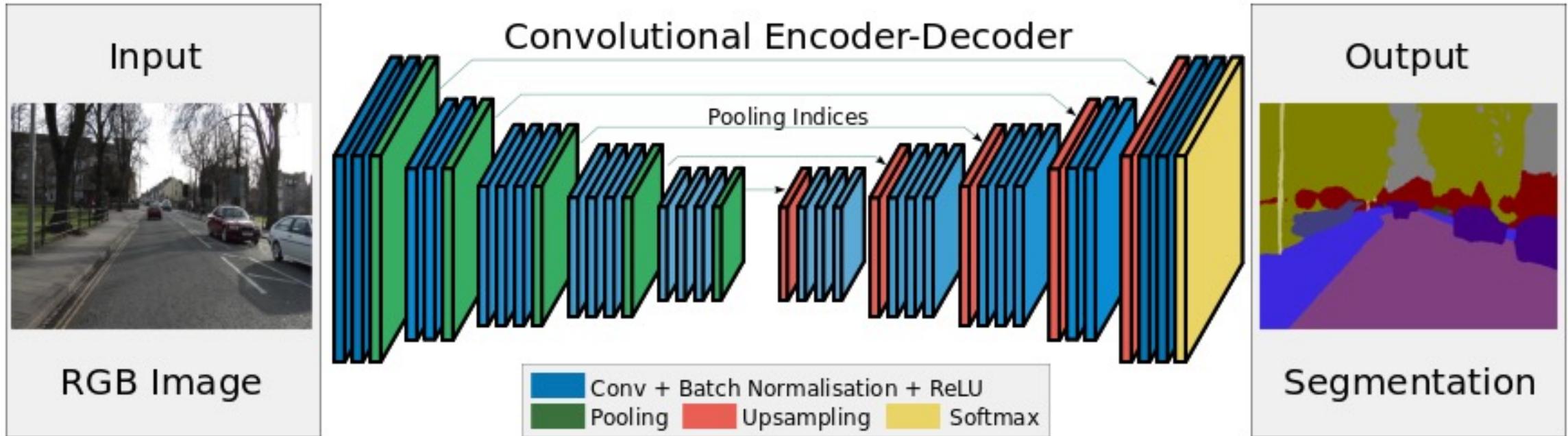
# Segmentation Architecture



SegNet (2015): fully convolutional architecture

Stage 1: Encoder identifies features

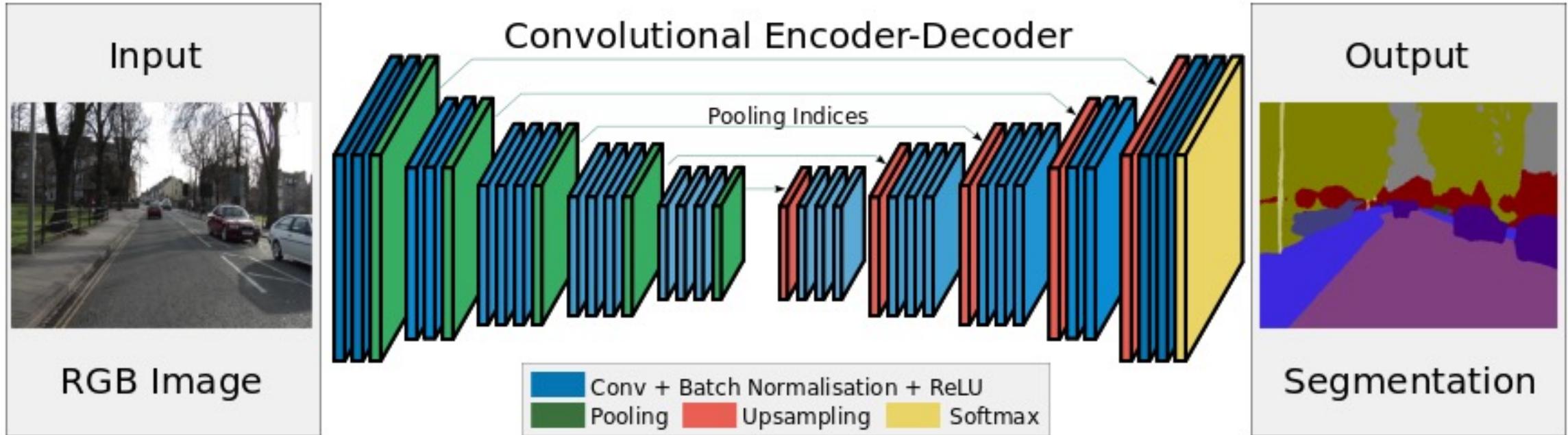
Stage 2: Decoder reconstructs the spatial map



Alternative architectures differ in their approach  
to the spatial reconstruction process

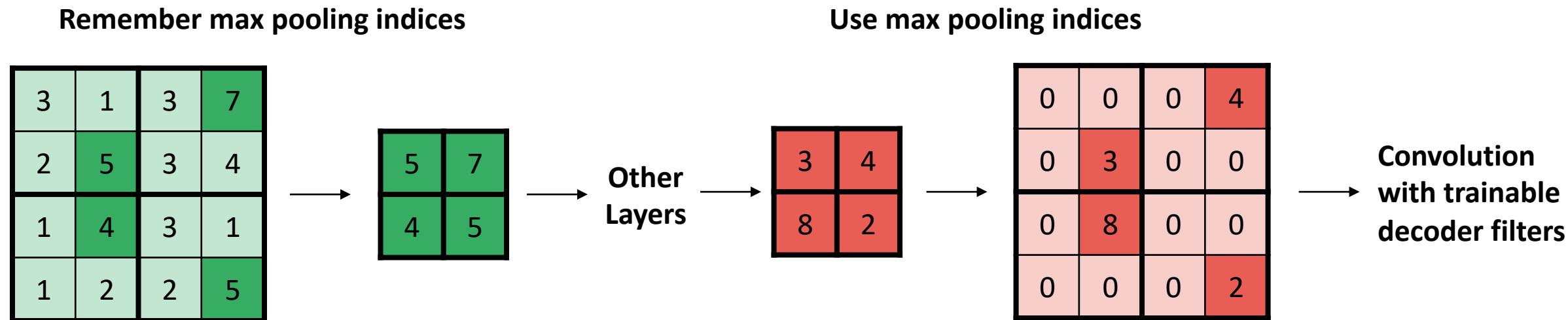
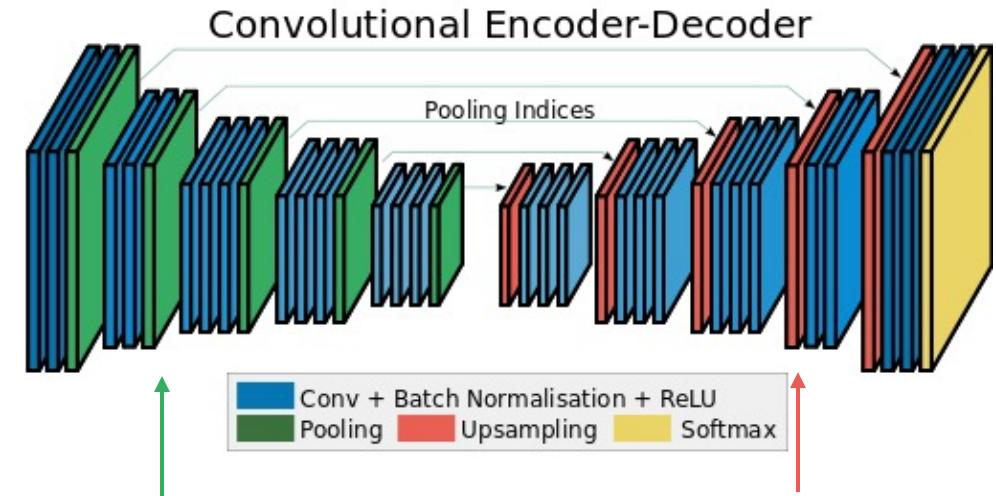
Stage 1: Encoder identifies features

Stage 2: Decoder reconstructs the spatial map

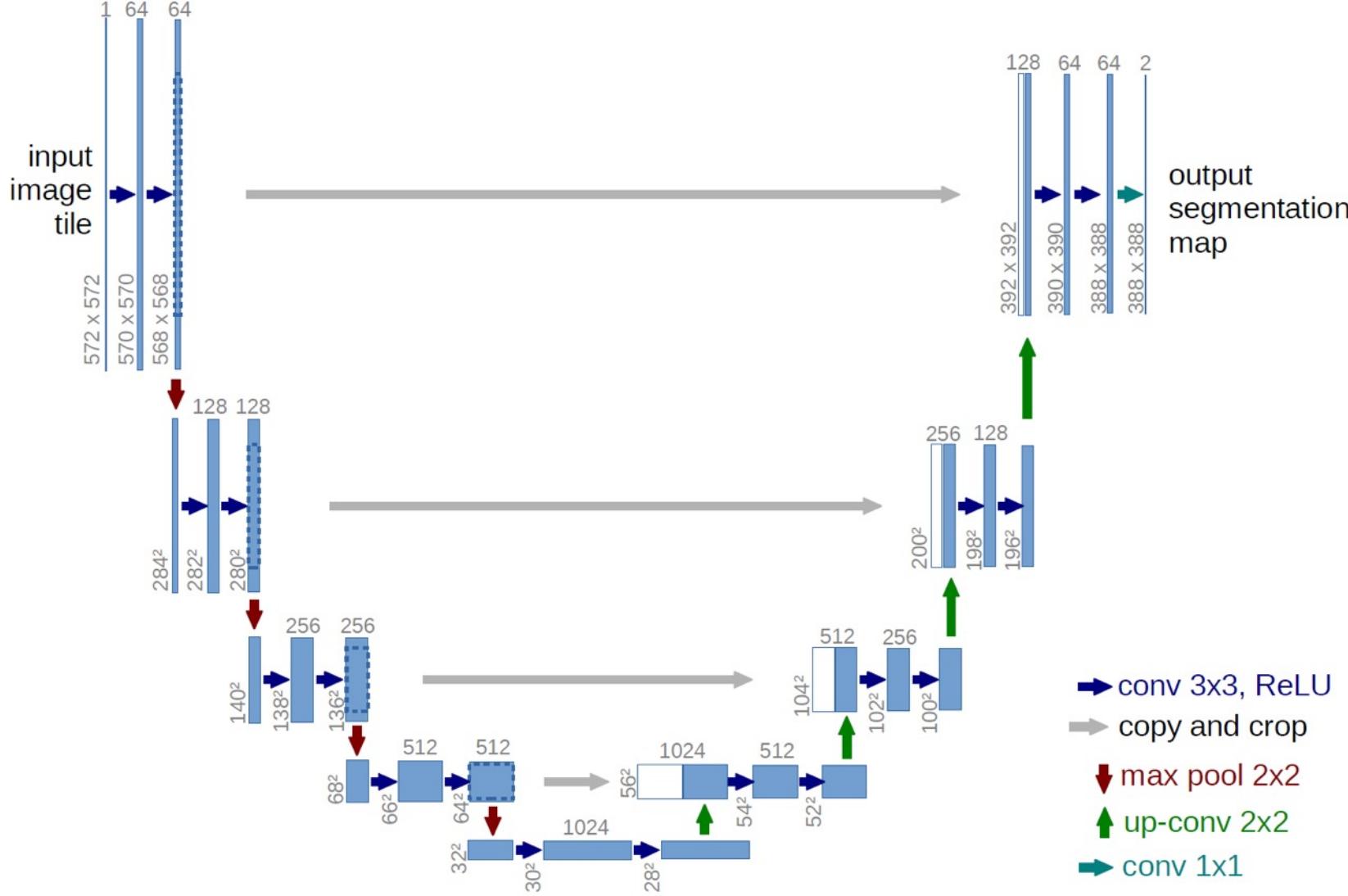


Segnet's approach to reconstruction: remember max-pooling indices

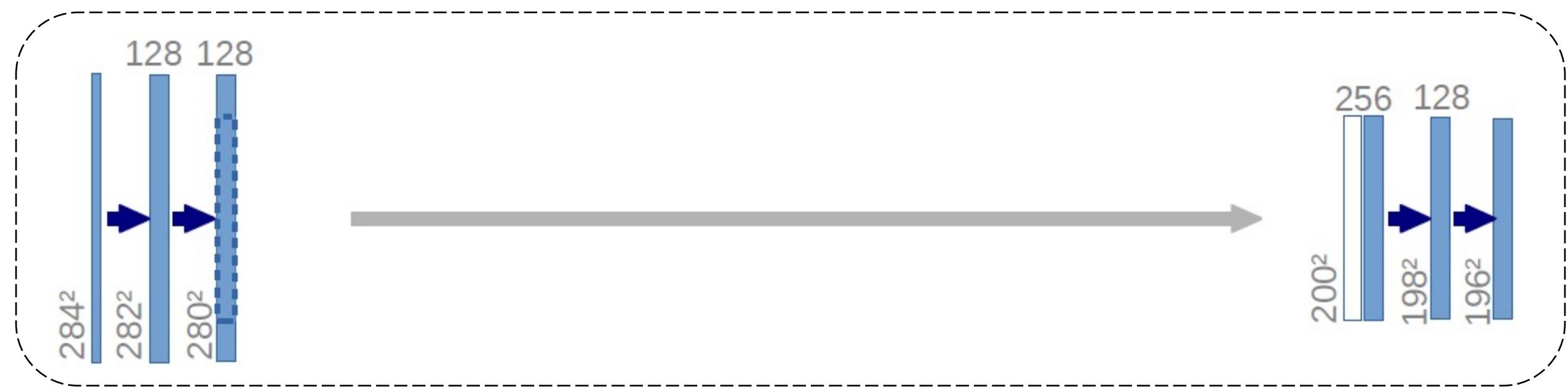
# SegNet decoder overview



# A Highly Successful Architecture: U-Net

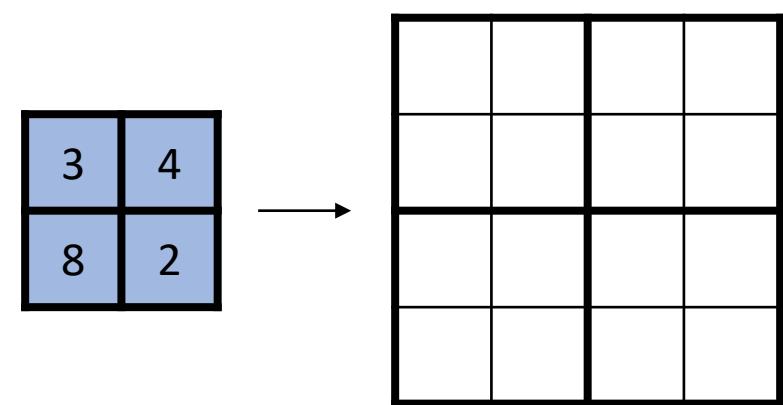
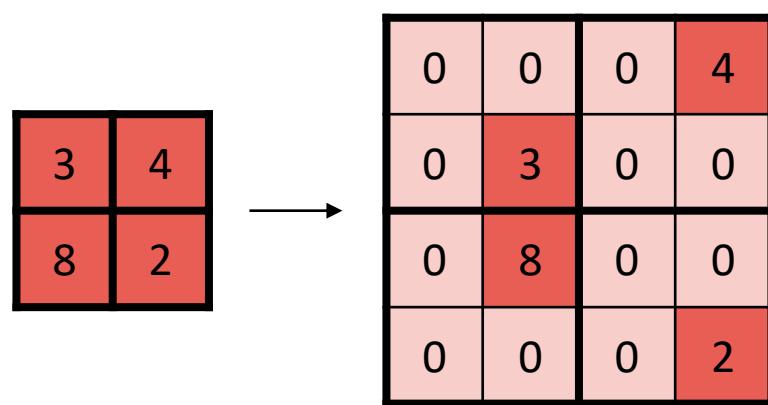


# Concatenation of corresponding encoder feature map

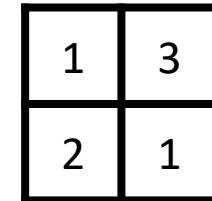


SegNet: Upsampling w/  
Stored Pooling Indices

U-Net: 2x2  
Upconvolution

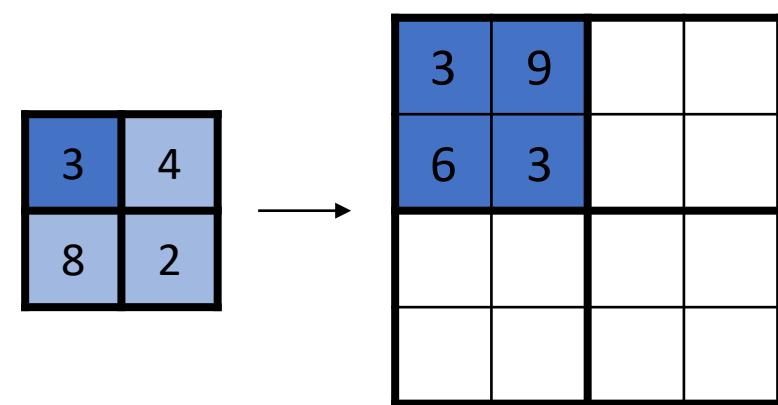
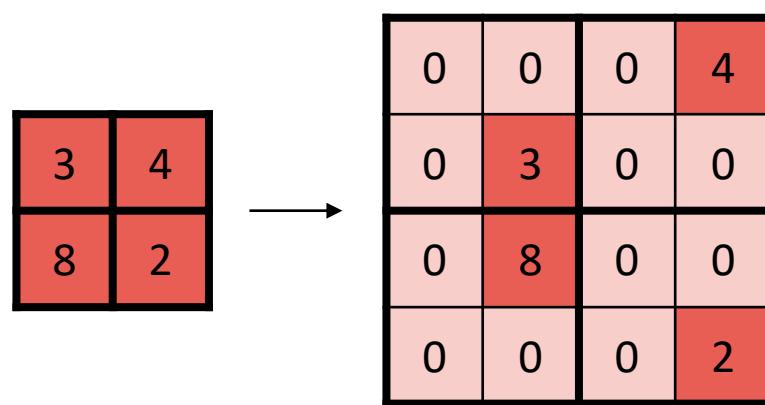


Learned filter

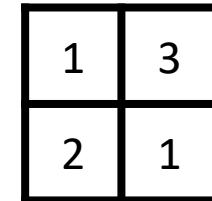


SegNet: Upsampling w/  
Stored Pooling Indices

U-Net: 2x2  
Upconvolution

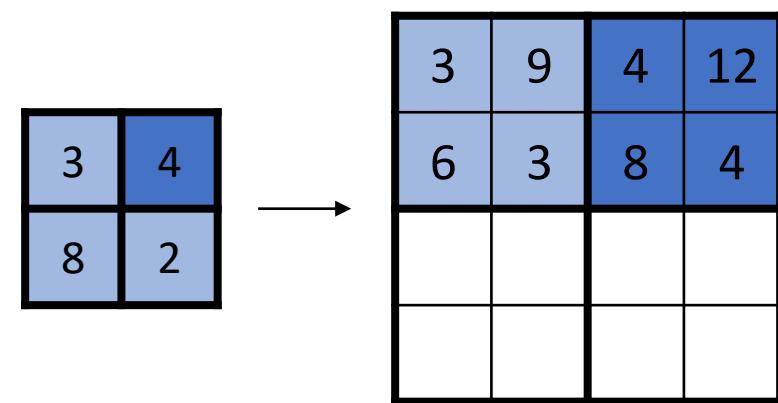
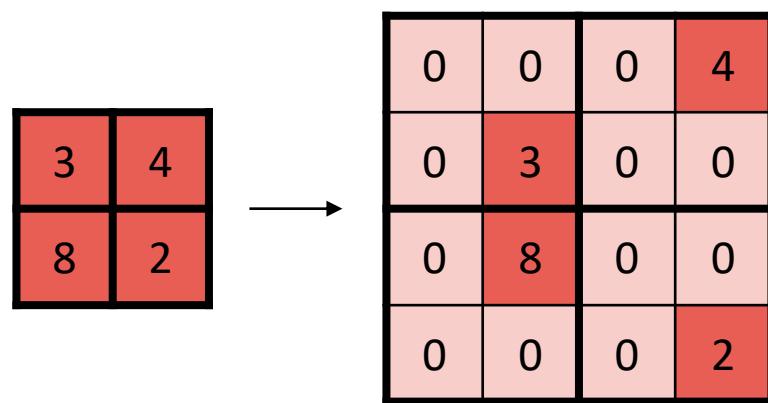


Learned filter



SegNet: Upsampling w/  
Stored Pooling Indices

U-Net: 2x2  
Upconvolution

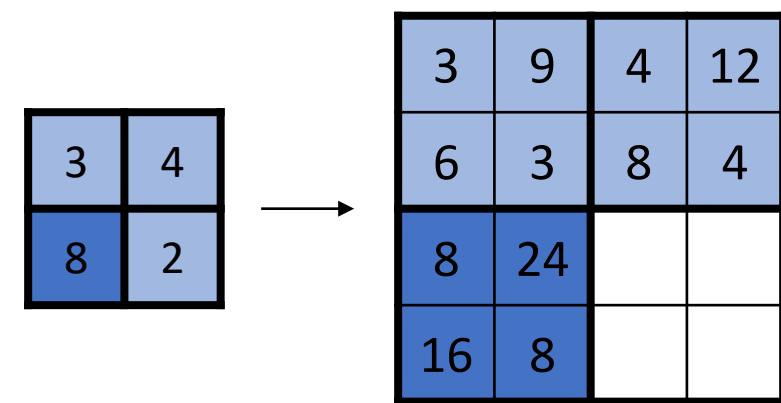
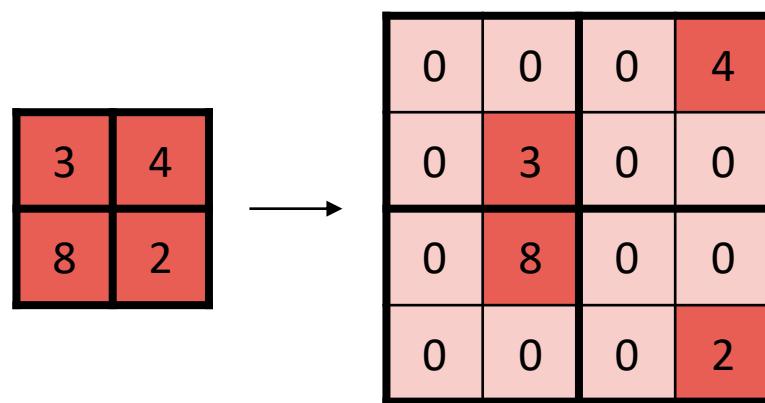


Learned filter

|   |   |
|---|---|
| 1 | 3 |
| 2 | 1 |

SegNet: Upsampling w/  
Stored Pooling Indices

U-Net: 2x2  
Upconvolution

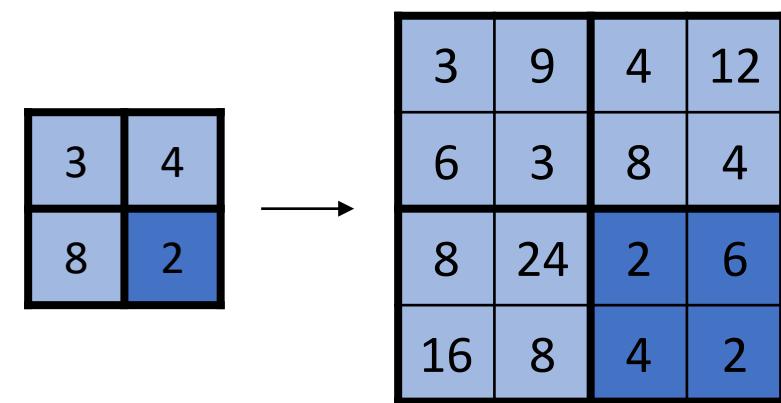
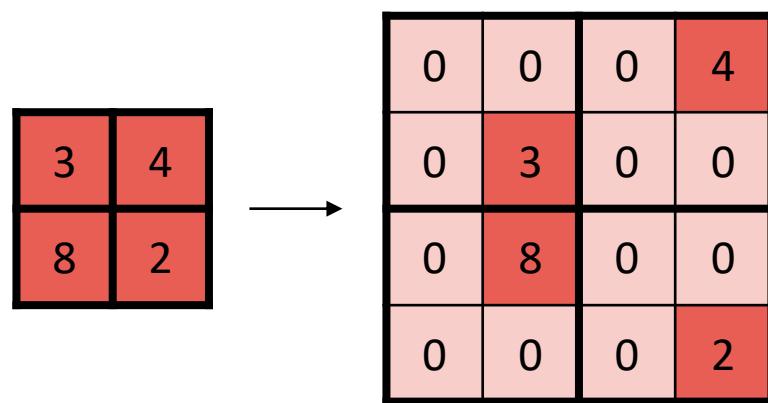


Learned filter

|   |   |
|---|---|
| 1 | 3 |
| 2 | 1 |

SegNet: Upsampling w/  
Stored Pooling Indices

U-Net: 2x2  
Upconvolution



Learned filter

|   |   |
|---|---|
| 1 | 3 |
| 2 | 1 |